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(54) **A noise reducer.**

(57) A noise reducer for outputting a noise-reduced signal by extracting noise included in an input video signal so as to produce a noise signal and by subtracting the noise signal from the input video signal is provided. The noise reducer includes: a signal processing portion which includes: a delay means for delaying the noise-reduced signal by a predetermined time period so as to output a delayed signal; a first subtracter for subtracting the delayed signal from the input video signal so as to output a differential signal; an orthogonal transformer for conducting orthogonal transformation on the differential signal, each of pixel blocks of the differential signal being transformed as a unit, so as to output an orthogonally transformed signal; a nonlinear processing portion for conducting nonlinear processing on the orthogonally transformed signal based on a predetermined threshold so as to output a nonlinear processed signal; an orthogonal inverse transformer for conducting an inverse transformation of the orthogonal transformation on the nonlinear processed signal so as to output an inversely transformed signal; and an attenuator for attenuating the inversely transformed signal by a predetermined coefficient so as to output the noise signal; a second subtracter for subtracting the noise signal from the input video signal so as to output the noise-reduced signal; and an adaptive control portion for controlling at least one of the predetermined threshold and the predetermined coefficient based on at least one of the differential signal and the orthogonally transformed signal.

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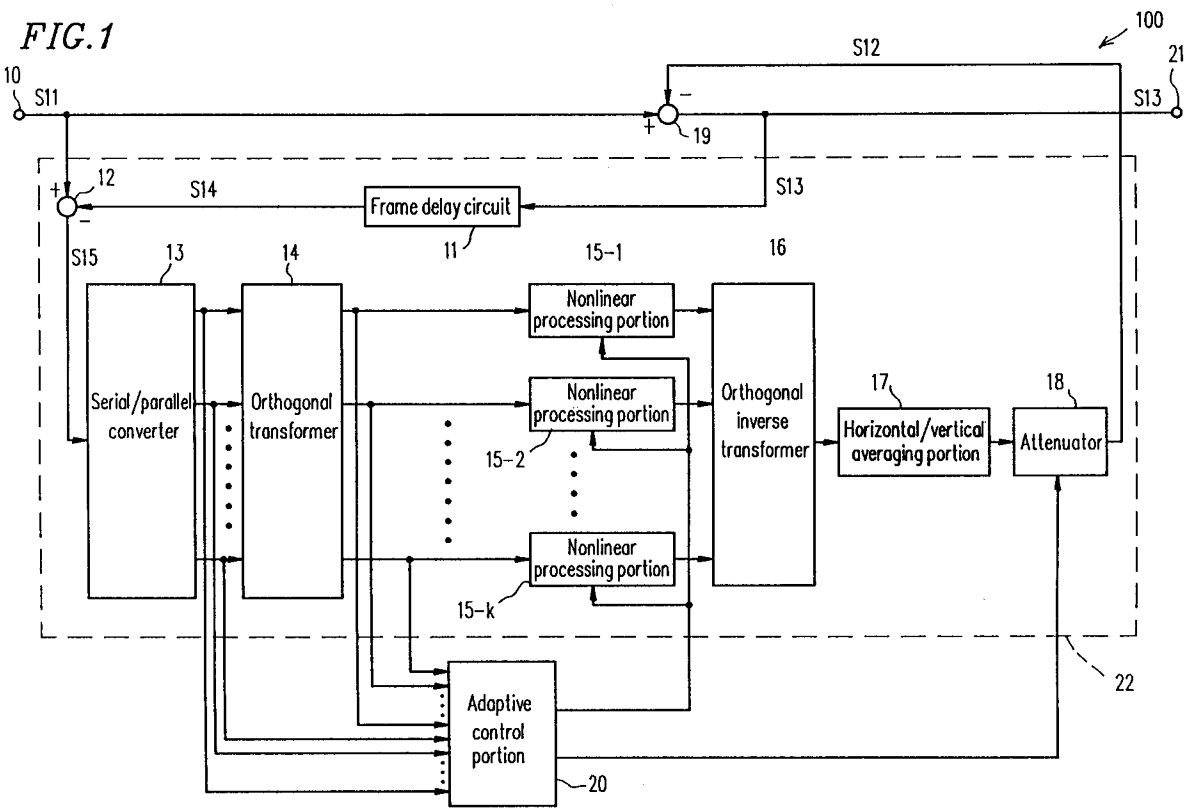
FIG.1


100
10
S11
S12
21
S13
19
12
S14
Frame delay circuit
S13
11
S15
13
14
15-1
16
Serial/parallel converter
Orthogonal transformer
Nonlinear processing portion
Nonlinear processing portion
15-2
Nonlinear processing portion
15-k
Orthogonal inverse transformer
17
Horizontal/vertical averaging portion
18
Attenuator
22
Adaptive control portion
20

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to a device for reducing noise included in a video signal, and more specifically, to a noise reducer capable of reducing noise effectively by controlling parameters for noise reduction.

2. Description of the Related Art:

With the recent progress in the field of semiconductor memories, inexpensive frame memories have become available. Using such frame memories, three-dimensional processing of video signals has been realized in various applications. As for noise reducers for home VTRs and TV receivers, many types using frame memories have been proposed. As one of such noise reducers, a frame recursive type noise reducer employing Hadamard transformation, which uses an orthogonal transformation, has been proposed, where the difference in the three-dimensional statistical characteristic between a video signal and random noise is utilized (The Journal of the Institute of Television Engineers of JAPAN, Vol. 37, No. 12, 1983, pp. 56-62).

A video signal without noise has large correlations in all of the horizontal, vertical, and temporal directions, while random noise has little correlation in any of the three directions. The noise reducer employing the Hadamard transformation utilizes this difference in the three-dimensional correlations between a video signal and random noise more effectively to reduce noise. The frame recursive type noise reducer employing the Hadamard transformation is advantageous over a simple frame recursive type noise reducer without using the Hadamard transformation in that the resolution of the motion picture portion of the transmission is less deteriorated under the condition where the improvement in the S/N ratio is the same.

A conventional frame recursive type noise reducer employing the Hadamard transformation will be described with reference to Figure **48**. A noise reducer **900** includes a noise extract portion **9** which extracts noise included in an input video signal **S1**, and a second subtracter **8** which subtracts an extracted noise signal **S2** from the input video signal **S1**, so as to obtain an output signal **S3** with reduced noise.

Referring to Figure **48**, the noise extract portion **9** includes a first subtracter **1**, a frame memory **2**, a serial/parallel converter **3**, an Hadamard transformer **4**, nonlinear processing portions **5-1** to **5-k** (hereinafter, collectively referred to as a nonlinear processor **5**, unless causing misunderstanding), an Hadamard inverse transformer **6**, and parallel/serial converter **7**. The frame memory **2** receives the output signal **S3** with reduced noise obtained by subtracting the noise signal **S2** extracted in the noise extract portion **9** from the input video signal **S1** as described above, and outputs a delayed signal **S4** by delaying the output signal **S3** by one frame or several frames. The first subtracter **1** subtracts the delayed signal **S4** from the input video signal **S1** so as to obtain a frame differential signal **S5**. The serial/parallel converter **3** converts a temporally serial data series (**S5**) into a temporally parallel data series **P1** corresponding to the order of the Hadamard transformation. The Hadamard transformer **4** conducts the Hadamard transformation on the parallel data series **P1** so as to obtain a data series **P2**. The nonlinear processor **5** conducts nonlinear processing on the Hadamard-transformed data series **P2** so as to obtain data **P3**. The Hadamard inverse transformer **6** conducts an Hadamard inverse transformation, i.e., an operation inverse to that conducted by the Hadamard transformer **4**, on the data **P3** so as to obtain a parallel data series **P4**. The parallel/serial converter **7** converts the parallel data series **P4** into a serial data series. The output from the parallel/serial converter **7** is the extracted noise signal **S2** output from the noise extract portion **9**. The second subtracter **8** subtracts the noise signal **S2** from the input video signal **S1**, so as to obtain the output signal **S3** with reduced noise.

The operation of the noise reducer **900** with the above configuration will be described in detail.

First, the first subtracter **1** calculates the difference between the input video signal **S1** and the delayed signal **S4** with reduced noise delayed by N frame(s) (N = 1, 2,...) by the frame memory **2**. Since random noise and a motion component included in the video signal have small correlation in the temporal direction, they are extracted by this differential operation and are output as the frame differential signal **S5** corresponding to the amplitude of the noise and the motion component. The serial/parallel converter **3** converts the temporally serial frame differential data (**S5**) into the temporally parallel data series **P1** composed of m sample points in the horizontal direction and n lines in the vertical direction (m, n = natural numbers). The serial/parallel converter 3 includes n-1 line memory or memories and (m-1) x n latch or latches.

Hereinbelow, the case where one pixel block is composed of m = 4 samples in the horizontal direction and n = 2 lines in the vertical direction will be described. A temporally parallel block (a pixel block composed of temporally parallel data) produced by the serial/parallel converter **3** is expressed in the form of matrix by formula (1):

$$\begin{bmatrix} X_{00} & X_{01} & X_{02} & X_{03} \\ X_{10} & X_{11} & X_{12} & X_{13} \end{bmatrix} \quad \cdots\cdots (1)$$

The block data composed of x_{00} to x_{03} and x_{10} to x_{13} will be described. When x_{00} is considered as the reference, x_{01}, x_{02}, and x_{03} are data located right of the reference by one sample, two samples, and three samples, respectively. Likewise, when x_{10} is considered as the reference, x_{11}, x_{12}, and x_{13} are data located right of the reference by one sample, two samples, and three samples, respectively. The data x_{10} to x_{13} are located below the data x_{00} to x_{03} by one line.

The Hadamard transformer **4** conducts the Hadamard transformation expressed by formula (2) below on the temporally parallel block data of four samples in the horizontal direction and two lines in the vertical direction, so as to obtain 4 (samples) x 2 (lines) = 8 frequency components in the Hadamard space.

$$\begin{aligned}
y_{00} &= x_{00}+x_{01}+x_{02}+x_{03}+x_{10}+x_{11}+x_{12}+x_{13} \\
y_{01} &= x_{00}-x_{01}+x_{02}-x_{03}+x_{10}-x_{11}+x_{12}-x_{13} \\
y_{02} &= x_{00}+x_{01}-x_{02}-x_{03}+x_{10}+x_{11}-x_{12}-x_{13} \\
y_{03} &= x_{00}-x_{01}-x_{02}+x_{03}+x_{10}-x_{11}-x_{12}+x_{13} \\
y_{10} &= x_{00}+x_{01}+x_{02}+x_{03}-x_{10}-x_{11}-x_{12}-x_{13} \\
y_{11} &= x_{00}-x_{01}+x_{02}-x_{03}-x_{10}+x_{11}-x_{12}+x_{13} \\
y_{12} &= x_{00}+x_{01}-x_{02}-x_{03}-x_{10}-x_{11}+x_{12}+x_{13} \\
y_{13} &= x_{00}-x_{01}-x_{02}+x_{03}-x_{10}+x_{11}+x_{12}-x_{13} \qquad (2)
\end{aligned}$$

wherein y_{ij} ($0 \leqq i \leqq 1$, $0 \leqq j \leqq 3$) represents the Hadamard-transformed data.

Since random noise has less correlation among data, it is uniformly distributed to the respective frequency components y_{ij} in the Hadamard space expressed by formula (2). The absolute value of each frequency component y_{ij} is input into the nonlinear processor **5**, which then extracts noise uniformly distributed to the respective frequency components y_{ij}. The relationship between the input and output of the nonlinear processor **5** is shown in Figure **49**, where the X-axis represents the input and the Y-axis represents the output. As is observed from Figure **49**, when the frequency component y_{ij} whoseabsolute value is equal to or more than a predetermined threshold A is input, the output is zero.

Thereafter, the noise component extracted by the nonlinear processor **5** is inverse-operated as expressed by formula (3) below by the Hadamard inverse transformer **6**, so as to return the data to the component in real space.

$$\begin{aligned}
x'_{00} &= (y'_{00}+y'_{01}+y'_{02}+y'_{03}+y'_{10}+y'_{11}+y'_{12}+y'_{13})/8 \\
x'_{01} &= (y'_{00}-y'_{01}+y'_{02}-y'_{03}+y'_{10}-y'_{11}+y'_{12}-y'_{13})/8 \\
x'_{02} &= (y'_{00}+y'_{01}-y'_{02}-y'_{03}+y'_{10}+y'_{11}-y'_{12}-y'_{13}/8 \\
x'_{03} &= (y'_{00}-y'_{01}-y'_{02}+y'_{03}+y'_{10}-y'_{11}-y'_{12}+y'_{13}/8 \\
x'_{10} &= (y'_{00}+y'_{01}+y'_{02}+y'_{03}-y'_{10}-y'_{11}-y'_{12}-y'_{13}/8 \\
x'_{11} &= (y'_{00}-y'_{01}+y'_{02}-y'_{03}-y'_{10}+y'_{11}-y'_{12}+y'_{13}/8 \\
x'_{12} &= (y'_{00}+y'_{01}-y'_{02}-y'_{03}-y'_{10}-y'_{11}+y'_{12}+y'_{13}/8 \\
x'_{13} &= (y'_{00}-y'_{01}-y'_{02}+y'_{03}-y'_{10}+y'_{11}+y'_{12}-y'_{13}/8 \qquad (3)
\end{aligned}$$

wherein x'_{ij} represents each component of the noise signal returned to the real space.

The noise component x'_{ij} is then converted into the temporally serial noise signal **S2** by the parallel/serial converter **7**. Thereafter, the second subtracter **8** subtracts the noise signal **S2** from the input video signal **S1** including noise. Thus, the noise is reduced by the conventional noise reducer **900**.

In the conventional noise reducer **900**, the threshold A for the input/output characteristic of the nonlinear processor **5** is fixed to a predetermined value as shown in Figure **49**. Accordingly, when the absolute value of a motion component included in the input video signal **S1** is comparatively small , i.e., equal to or less than the threshold A, the nonlinear processor **5** extracts the motion component as noise, causing a phenomenon such as lag and trailing on the moving picture displayed. On the contrary, when the amplitude of noise is considerably large, since the portion of such noise of which absolute value exceeds the threshold A is not extracted, the noise signal **S2** returned from the nonlinear processor **5** is smaller than the original noise included in the input video signal **S1**. As a result, a sufficient noise reduction effect is not obtained. Further, when the input video signal **S1** includes little noise or the noise has a small amplitude, the motion component of the video signal is extracted and subtracted from the input video signal and this results in causing a phenomenon such as lag and trailing in the displayed motion picture more prominent because the influence of the noise itself is smaller.

SUMMARY OF THE INVENTION

The noise reducer for outputting a noise-reduced signal by extracting noise included in an input video signal so as to produce a noise signal and by subtracting the noise signal from the input video signal is provided. The noise reducer of this invention includes: a signal processing portion including: a delay circuit for delaying the noise-reduced signal by a predetermined time period so as to output a delayed signal; a first subtracter for subtracting the delayed signal from the input video signal so as to output a differential signal; an orthogonal transformer for receiving the differential signal and conducting an orthogonal transformation on the differential signal, each of the pixel blocks of the differential signal being transformed as a unit, so as to output an orthogonally transformed signal; a nonlinear processing portion for receiving the orthogonally transformed signal and conducting nonlinear processing on the orthogonally transformed signal based on a predetermined threshold so as to output a nonlinear processed signal; an orthogonal inverse transformer for receiving the nonlinear processed signal and conducting an inverse transformation of the orthogonal transformation on the nonlinear processed signal so as to output an inversely transformed signal; and an attenuator for receiving the inversely transformed signal and attenuating the inversely transformed signal by a predetermined coefficient so as to output the noise signal; a second subtracter for subtracting the noise signal from the input video signal so as to output the noise-reduced signal; and an adaptive control portion for controlling at least one of the predetermined threshold and the predetermined coefficient based on at least one of the differential signal and the orthogonally transformed signal.

In one embodiment of the invention, the input video signal is composed of serial data, and the signal processing portion further includes: a serial/parallel converter for converting the differential signal into a parallel signal and outputting the parallel signal to the orthogonal transformer, each of the pixel blocks being output as a unit; and an averaging portion for averaging the inversely transformed signal based on the predetermined time period so as to convert the inversely transformed signal into serial data and outputting the serial data of the inversely transformed signal to the attenuator.

In another embodiment of the invention, the adaptive control portion includes: a motion amount determination portion for determining at least the amount of motion of the input video signal in the predetermined time period based on the differential signal and/or the orthogonally transformed signal; and a parameter control portion for controlling at least one of the predetermined threshold and the predetermined coefficient based on the amount of motion.

In another embodiment of the invention, the motion amount determination portion includes an absolute value calculation circuit for receiving the differential signal for each of the pixel blocks composed of m samples in a horizontal direction and n lines in a vertical direction (m, n = natural numbers) and calculating the absolute value of data of the differential signal at each sample point of the pixel block, and an average calculator for calculating the average of the absolute values, and the parameter control portion which includes a first control portion for controlling the predetermined threshold for the nonlinear processing portion based on an output from the average calculator, and a second control portion for controlling the predetermined coefficient for the attenuator based on the output from the average calculator.

In another embodiment of the invention, the motion amount determination portion includes an absolute value calculation circuit for receiving the orthogonally transformed signal and calculating the absolute value of each component of the orthogonally transformed signal, and a dispersion parameter calculator for calculating a dispersion parameter representing the degree of dispersion of the absolute value, and the parameter control portion which includes a first control portion for controlling the predetermined threshold for the nonlinear processing portion based on an output from the dispersion parameter calculator, and a second control portion for controlling the predetermined coefficient for the attenuator based on the output from the dispersion parameter calculator.

In another embodiment of the invention, the motion amount determination portion includes an absolute value calculation circuit for receiving the orthogonally transformed signal and calculating the absolute values of k components (k = natural number) of the orthogonally transformed signal, and the parameter control portion which includes a first control portion for controlling the predetermined threshold for the nonlinear processing portion based on at least one of the outputs from the k absolute value calculation circuit, and a second control portion for controlling the predetermined coefficient for the attenuator based on at least one of the outputs from the k absolute calculation circuit.

In another embodiment of the invention, the motion amount determination portion includes an isolated-point removal circuit for receiving the orthogonally transformed signal and removing isolated points from the i components among the k components (i = natural number less than k, k = natural number equal to or more than 2) of the orthogonally transformed signal, a first absolute value calculation circuit for calculating absolute values of the i components output from the isolated-point removal portion, and a second absolute value calculation circuit for calculating absolute values of the (k - i) components on which isolated-point removal is not conducted, and the parameter control portion which includes a first control portion for controlling the predetermined threshold for the nonlinear processing portion based on an output from the first absolute value calculation circuit and/or the second absolute value calculation circuit, and a second control portion for controlling the predetermined coefficient for the attenuator based on the output from the first absolute value calculation circuit and/or the second absolute value calculation circuit.

In another embodiment of the invention, the isolated-point removal portion includes a filter for determining whether or not each of the i components of the orthogonally transformed signal is isolated in at least one of three directions corresponding to a horizontal direction, a vertical direction, and a temporal direction of the pixel block, and outputting a modified value for the component when the component is determined as being isolated.

In another embodiment of the invention, the noise reducer further includes an additional control portion for receiving the differential signal, detecting the amplitude of noise included in the differential signal, and outputting the amplitude of the noise to the adaptive control portion as an additional control signal for further adjusting the predetermined threshold and/or the predetermined coefficient.

In another embodiment of the invention, the noise reducer further includes an additional control portion for receiving the input video signal, extracting a predetermined parameter from the input video signal, and outputting the extracted parameter to the adaptive control portion as an additional control signal for further adjusting at least one of the predetermined threshold and the predetermined coefficient.

In another embodiment of the invention, the parameter extracted by the additional control portion is one of the type, amplitude, or level of the input video signal.

According to another aspect of the invention, the noise reducer for outputting noise-reduced signal by extracting noise included in an input video signal so as to produce a noise signal and by subtracting the noise signal from the input video signal, the noise reducer includes: a signal processing portion which includes: a first delay circuit for delaying the noise-reduced signal by a predetermined time period so as to output a first delayed signal; a first subtracter for subtracting the first delayed signal from the input video signal to output a differential signal; an orthogonal transformer for receiving the differential signal and a second delayed signal and conducting an orthogonal transformation on the differential signal and the second delayed signal, each of the pixel blocks of the differential signal and the second delayed signal being transformed as a unit, so as to output an orthogonally transformed signal; a nonlinear processing portion for receiving the orthogonally transformed signal and conducting nonlinear processing on the orthogonally transformed signal based on a predetermined threshold so as to output a nonlinear processed signal; an orthogonal inverse transformer for receiving the nonlinearly processed signal and conducting an inverse transformation of the orthogonal transformation on the nonlinearly processed signal so as to output an inversely transformed signal; an attenuator for receiving the inversely transformed signal and attenuating the inversely transformed signal by a predetermined coefficient to output the noise signal; and a second delay circuit for delaying the inversely transformed signal by another predetermined time period to output the second delayed signal; a second subtracter for subtracting the noise signal from the input video signal to output the noise-reduced signal; and an adaptive control portion for controlling the predetermined threshold and/or the predetermined coefficient based on the differential signal and/or the orthogonally transformed signal.

In one embodiment of the invention, the input video signal and the second delayed signal are serial data, and the signal processing portion further includes: a serial/parallel converter for converting the differential signal and the second delayed signal into a parallel signal and outputting the parallel signal to the orthogonal transformer, each of the pixel blocks being output as a unit; and an averaging portion for averaging the inversely transformed signal based on the predetermined time period to convert the inversely transformed signal into serial data and outputting the serial data of the inversely transformed signal to the attenuator and the second delay circuit.

In another embodiment of the invention, the adaptive control portion includes: a motion amount determination portion for determining at least the amount of motion of the input video signal in the predetermined time period based on at least one of the combination of the differential signal and the second delayed signal and the orthogonally transformed signal; and a parameter control portion for controlling at least one of the predetermined threshold and the predetermined coefficient based on the amount of motion.

In another embodiment of the invention, the motion amount determination portion includes an absolute value calculation circuit for receiving the differential signal and the second delayed signal for each of the pixel blocks composed of m samples in a horizontal direction and n lines in a vertical direction (m, n = natural numbers) and calculating the absolute value of data of the differential signal at each sample point of the pixel block, and an average calculator for calculating the average of the absolute values, and the parameter control portion includes a first control portion for controlling the predetermined threshold for the nonlinear processing portion based on an output from the average calculator, and a second control portion for controlling the predetermined coefficient for the attenuator based on the output from the average calculator.

In another embodiment of the invention, the motion amount determination portion includes an absolute value calculation circuit for receiving the orthogonally transformed signal and calculating the absolute value of each component of the orthogonally transformed signal, and a dispersion parameter calculator for calculating a dispersion parameter representing the degree of dispersion of the absolute value, and the parameter control portion includes a first control portion for controlling the predetermined threshold for the nonlinear processing portion based on an output from the dispersion parameter calculator, and a second control portion for controlling the predetermined coefficient for the attenuator based on the output from the dispersion parameter calculator.

In another embodiment of the invention, the motion amount determination portion includes an absolute value calculation circuit (k = natural number) for receiving the orthogonally transformed signal and calculating the absolute values of the k components of the orthogonally transformed signal, and the parameter control portion includes a first control portion for controlling the predetermined threshold for the nonlinear processing portion based on at least one of outputs from the k absolute value calculation circuit, and a second control portion for controlling the predetermined coefficient for the attenuator based on at least one of the outputs from the k absolute calculation circuit.

In another embodiment of the invention, the motion amount determination portion includes an isolated-point removal portion for receiving the orthogonally transformed signal and removing isolated points from the i components among the k components (i = natural number less than k, k = natural number equal to or greater than 2) of the orthogonally transformed signal, a first absolute value calculation circuit for calculating absolute values of the i components output from the isolated-point removal portion, and a second absolute value calculation circuit for calculating absolute values of the (k - i) components on which isolated-point removal is not conducted, and the parameter control portion includes a first control portion for controlling the predetermined threshold for the nonlinear processing portion based on an output from the first absolute value calculation circuit and/or the second absolute value calculation circuit, and a second control portion for controlling the predetermined coefficient for the attenuator based on the output from the first absolute value calculation circuit and/or the second absolute value calculation circuit.

In another embodiment of the invention, the isolated-point removal portion includes a filter for controlling whether or not each i component of the orthogonally transformed signal is isolated in at least one of three directions corresponding to a horizontal direction, a vertical direction, and a temporal direction of the pixel block, and outputting a modified value for the component when the component is determined as being isolated.

In another embodiment of the invention, the noise reducer further includes a control portion for receiving the differential signal, detecting the amplitude of noise included in the differential signal, and outputting the amplitude of the noise to the adaptive control portion as an additional control signal for further adjusting at least one of the predetermined threshold and the predetermined coefficient.

In another embodiment of the invention, the noise reducer further includes an additional control portion for receiving the input video signal, extracting a predetermined parameter from the input video signal, and outputting the extracted parameter to the adaptive control portion as an additional control signal for further adjusting at least one of the predetermined threshold and the predetermined coefficient.

In another embodiment of the present invention, the parameter extracted by the additional control portion is one of the type, amplitude, and level of the input video signal.

Thus, the invention described herein makes possible the advantages of (1) providing a noise reducer capable of reducing the deterioration in the quality of the moving picture portion of an image and also reducing noise effectively in both the moving picture portion and the still picture portion of the image by controlling at least one of the threshold for a nonlinear processor and the amount of attenuation at an attenuator according to the motion amount of a video signal and thus adjusting a feedback noise signal, and

(2) providing a noise reducer where the threshold and the amount of attenuation is further controlled according to the amount of noise included in the video signal and the characteristic and type of the video signal.

These and other advantages of the present invention will become apparent to those skilled in the art upon reading and understanding the following detailed description with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure **1** is a block diagram of the noise reducer according to the present invention.

Figure **2** is a block diagram of the noise reducer according to the present invention shown in more detail.

Figure **3** is a block diagram of a serial/parallel converter of the noise reducer according to the present invention.

Figure **4** explains a concept of the data from a pixel block on a screen.

Figure **5** is a block diagram of a horizontal/vertical averaging portion according to the present invention.

Figures **6A** to **6D** show the input/output characteristics of a nonlinear processor according to the present invention.

Figure **7** shows pixel block data output from an orthogonal inverse transformer according to the present invention.

Figure **8** describes the horizontal averaging operation.

Figure **9** is a block diagram of a motion amount determination portion of a noise reducer of the first example according to the present invention.

Figure **10** is a block diagram of an average value calculator according to the first example.

Figure **11** shows the control characteristic of a first control portion according to the first example.

Figure **12** shows the control characteristic of a second control portion according to the first example.

Figure **13** is a block diagram of a motion amount determination portion of a noise reducer of the second example according to the present invention.

Figure **14** is a block diagram of a dispersion parameter calculator according to the second example.

Figure **15** is a block diagram of another dispersion parameter calculator according to the second example.

Figures **16A** and **16B** show the relationship between the degree of dispersion and the dispersion parameter according to the second example.

Figure **17** shows the control characteristic of a first control portion according to the second example.

Figure **18** shows the control characteristic of a second control portion according to the second example.

Figure **19** is a block diagram of a motion amount determination portion of a noise reducer of the third example according to the present invention.

Figure **20** shows the control characteristic of a first control portion according to the third example.

Figure **21** shows the control characteristic of a second control portion according to the third example.

Figure **22** is a block diagram of a motion amount determination portion of a noise reducer of the fourth example according to the present invention.

Figure **23** is a block diagram of an isolated-point removal portion according to the fourth example.

Figure **24** is a block diagram of another isolated-point removal portion according to the fourth example.

Figure **25** is a block diagram of yet another isolated-point removal portion according to the fourth example.

Figure **26** shows the control characteristic of a first control portion according to the fourth example.

Figure **27** shows the control characteristic of a second control portion according to the fourth example.

Figure **28** is a block diagram of a motion amount determination portion of a noise reducer of the fifth example according to the present invention.

Figure **29** is a block diagram of a noise amplitude detection portion according to the fifth example.

Figures **30A** to **30D** show waveforms of a signal processed by the noise amplitude detection portion according to the fifth example.

Figure **31** shows the control characteristics of a first control portion according to the fifth example.

Figure **32** shows the control characteristics of a second control portion according to the fifth example.

Figure **33** is a block diagram of a motion amount determination portion of a noise reducer of the sixth example according to the present invention.

Figure **34** is a block diagram of a signal amplitude detection portion according to the sixth example.

Figure **35** shows the control characteristics of a first control portion according to the sixth example.

Figure **36** shows the control characteristics of a second control portion according to the sixth example.

Figure **37** is a block diagram of a motion amount determination portion of a noise reducer of the seventh example according to the present invention.

Figure **38** is a block diagram of a signal level detection portion according to the seventh example.

Figure **39** shows the control characteristics of a first control portion according to the seventh example.

Figure **40** shows the control characteristics of a second control portion according to the seventh example.

Figure **41** is a block diagram of a motion amount determination portion of a noise reducer of the eighth example according to the present invention.

Figure **42** shows the control characteristics of a first control portion according to the eighth example.

Figure **43** shows the control characteristics of a second control portion according to the eighth example.

Figure **44** is a block diagram of a noise reducer of the ninth example according to the present invention.

Figure **45** is a block diagram of the noise reducer of the ninth example shown in more detail.

Figure **46** is a block diagram of a horizontal averaging portion according to the ninth example.

Figure **47** illustrates a process of producing a pixel block using a signal output from the horizontal averaging portion and a frame differential signal.

Figure **48** is a block diagram of a conventional noise reducer.

Figure **49** shows the input/output characteristic of a nonlinear processor of a conventional noise reducer.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The noise reducer of the present invention will be described by way of examples with reference to the accompanying drawings as follows.

Figure **1** is a block diagram of a noise reducer **100** which inclusively shows noise reducers of Examples 1 to 8. Referring to Figure **1**, the noise reducer **100** of the present invention includes a signal processing portion **22** which extracts noise included in an input video signal **S11**, and a second subtracter **19** which subtracts an extracted noise signal **S12** from the input video signal **S11**, so as to obtain a noise-reduced output signal **S13**. The noise reducer **100** further includes an adaptive control portion **20** which controls at least a parameter used for noise reduction according to the amount of a motion component included in the input video signal **S11**.

Figure **2** shows a noise reducer **200** where the adaptive control portion **20** in Figure **1** is shown more specifically. The basic configurations of the noise reducers of Examples 1 to 4 are the same as the noise reducer **200** of Figure **2**. The noise reducer of the present invention may be provided with an additional control system for adjusting the parameter for noise reduction so as to achieve more effective and precise noise reduction. Such an additional control system will be described in Examples 5 to 9.

The configuration and the operation of the components of the noise reducer **200** which are common to Examples 1 to 4 will now be described. Referring to Figure **2**, the noise reducer **200** includes the signal processing portion **22** having a frame delay circuit **11**, a first subtracter **12**, a serial/parallel converter **13**, an orthogonal transformer **14**, nonlinear processing portions **15-1** to **15-k** (hereinafter, collectively referred to as a nonlinear processor **15**, unless this causes misunderstanding), an orthogonal inverse transformer **16**, a horizontal/vertical averaging portion **17**, and an attenuator **18**; and the adaptive control portion **20** having a motion amount determination portion **30**, a first control portion **31**, and a second control portion **32**.

As shown in Figure **2**, the input video signal **S11** is input from an input terminal **10**. The signal processing portion **22** extracts a noise component included in the input video signal **S11** and outputs the noise signal **S12**. The second subtracter **19** subtracts the noise signal **S12** from the input video signal **S11** and outputs the noise-reduced output signal **S13**.

The frame delay circuit **11** which is connected to the second subtracter **19** receives the noise-reduced output signal **S13** from the second subtracter **19**, and outputs a delayed signal **S14** by delaying the output signal **S13** by N frame(s) (N = 1, 2, ...). The first subtracter **12** which is connected to the input terminal **10** and the frame delay circuit **11** subtracts the delayed signal **S14** from the input video signal **S11** so as to obtain a frame differential signal **S15**.

The serial/parallel converter **13** which is connected to the first subtracter **12** converts a temporally serial data series of the frame differential signal **S15** into a temporally parallel data series so as to produce a pixel block of data for the orthogonal transformation. One pixel block is composed of m samples in the horizontal direction and n lines in the vertical direction (m, n = natural numbers). In this example, the case where one pixel block is composed of m = 4 samples in the horizontal direction and n = 2 lines in the vertical direction will be described, though the size of the pixel block is not limited to the above case. Figure **3** shows an example of the configuration of the serial/parallel converter 13. The serial/parallel converter 13 includes six one-sample delay circuits **101-1** to **101-6** and a one-line delay circuit **102**. The pixel block produced by the serial/parallel converter **13** is shown in Figure **4**, which will be described later in detail.

Referring to Figure **2** again, the orthogonal transformer **14** which is connected to the serial/parallel converter **13** conducts orthogonal transformation on the data of the pixel block produced by the serial/parallel converter **13**. In this example, the Hadamard transformation is employed as the orthogonal transformation conducted by the orthogonal transformer **14**. The Hadamard transformation is advantageous in that the transformation can be implemented with a simple circuit and the circuit can be used for both the transformation and the inverse transformation. Other types of orthogonal transformation such as discrete cosine transformation (DCT) and Harr transformation can also be used.

The nonlinear processor **15** is composed of k (k = m x n) nonlinear processing portions **15-1** to **15-k** corresponding to the respective data of the pixel block, and connected to the orthogonal transformer **14**. The nonlinear processor **15** conducts nonlinear processing on the orthogonal-transformed data so as to extract a noise component. The orthogonal inverse transformer **16** which is connected to the nonlinear processor **15** conducts an orthogonal inverse transformation on the data extracted as the noise component.

The horizontal/vertical averaging portion **17** which is connected to the orthogonal inverse transformer **16** receives the temporally parallel data series (pixel block of data) composed of m samples horizontally in n lines vertically which has been subjected to the orthogonal transformation. The horizontal/vertical averaging portion **17** averages the data corresponding to an identical pixel position on the screen and included in different pixel blocks, so that the received parallel data of the pixel block is converted into temporally serial data. Figure **5** shows an example of the configuration of the horizontal/vertical averaging portion **17**, which includes one-sample delay circuits **201-1** to **201-6**, a one-line delay circuit **202**, adders **203-1** to **203-7**, and a multiplier **204** which multiplies the output from the adder **203-7** by 1/8. The operation thereof will be described later in detail.

Referring back to Figure **2** again, the attenuator **18** which is connected to the horizontal/vertical averaging portion **17** lowers the gain of the output from the horizontal/vertical averaging portion **17**. The second subtracter **19** which is connected to the input terminal **10**, the attenuator **18**, and the frame delay circuit **11** subtracts the noise signal **S12** (the output from the attenuator **18**) from the input video signal **S11** so as to reduce a noise component of the input video signal **S11**. The output signal **S13** with reduced noise is supplied to the frame delay circuit **11**, as well as being output to an output terminal **21**.

The motion amount determination portion **30** of the adaptive control portion **20** which is connected to the serial/parallel converter **13** and the orthogonal transformer **14** determines the amount of the motion component (motion amount) of the input video signal **S11** based on at least one of the signals supplied from the serial/parallel converter **13** and the orthogonal transformer **14**. The first and second control portions **31** and **32** control parameters for the nonlinear processor **15** and the attenuator **18**, respectively, based on the output from the motion amount determination portion **30**. In Figure **2**, the first and second control portions **31** and **32** are shown as separated portions. However, they may be constructed as one circuit.

The operation of the noise reducer **200** common to Examples 1 to 4 will be described in more detail.

The input video signal **S11** including noise is input from the input terminal **10**. The first subtracter **12** calculates the difference between the input video signal **S11** and the delayed signal **S14** delayed by N frame(s) (N = 1, 2, ...) by the frame delay circuit **11**, and outputs random noise and a motion component included in the input video signal **S11** as the frame differential signal **S15**. This differential operation is possible because the random noise and the motion component have small correlations among frames (i.e., along the temporal axis). The frame differential signal **S15** is generated according to the amplitudes of the noise and the motion component. Accordingly, the output from the first subtracter **12** is zero when the input video signal is in the still picture portion without noise.

The output from the first subtracter **12** (the frame differential signal **S15**) is temporally serial data including the noise and the motion component. The serial/parallel converter **13** converts the serial data into temporally parallel data composed of m sample points horizontally in n lines vertically (m, n = natural numbers). The serial/parallel converter **13** includes n-1 one-line delay circuit(s) and (m-1) x n one-sample delay circuit(s). Hereinbelow, the case where one pixel block is composed of m = 4 samples horizontally in n = 2 lines vertically will be described. A temporally parallel block produced by the serial/parallel converter **13** is expressed in the form of a matrix by formula (4):

$$\begin{bmatrix} X_{00} & X_{01} & X_{02} & X_{03} \\ X_{10} & X_{11} & X_{12} & X_{13} \end{bmatrix} \quad \cdots\cdots (4)$$

Referring to Figure **4**, the pixel block composed of data x_{00} to x_{03} and x_{10} to x_{13} will be described. Figure **4** shows the pixel block composed of four samples and two lines. When x_{00} is considered as the reference, x_{01}, x_{02}, and x_{03} are data located right of the reference by one sample, two samples, and three samples, respectively. Likewise, when x_{10} is considered as the reference, x_{11}, x_{12}, and x_{13} are data located right of the reference by one sample, two samples, and three samples, respectively. The data x_{10} to x_{13} are located below the data x_{00} to x_{03} by one line.

The parallel converted 4 x 2 data y_{ij} ($0 \leqq i \leqq 1$, $0 \leqq j \leqq 3$) of the pixel block is then subjected to the Hadamard transformation by the orthogonal transformer **14**. The Hadamard-transformed data (signal components in the Hadamard space) y_{ij} ($0 \leqq i \leqq 1$, $0 \leqq j \leqq 3$) are expressed by formula (5):

$$\begin{aligned}
y_{00} &= x_{00}+x_{01}+x_{02}+x_{03}+x_{10}+x_{11}+x_{12}+x_{13} \\
y_{01} &= x_{00}-x_{01}+x_{02}-x_{03}+x_{10}-x_{11}+x_{12}-x_{13} \\
y_{02} &= x_{00}+x_{01}-x_{02}-x_{03}+x_{10}+x_{11}-x_{12}-x_{13} \\
y_{03} &= x_{00}-x_{01}-x_{02}+x_{03}+x_{10}-x_{11}-x_{12}+x_{13} \\
y_{10} &= x_{00}+x_{01}+x_{02}+x_{03}-x_{10}-x_{11}-x_{12}-x_{13} \\
y_{11} &= x_{00}-x_{01}+x_{02}-x_{03}-x_{10}+x_{11}-x_{12}+x_{13} \\
y_{12} &= x_{00}+x_{01}-x_{02}-x_{03}-x_{10}-x_{11}+x_{12}+x_{13} \\
y_{13} &= x_{00}-x_{01}-x_{02}+x_{03}-x_{10}+x_{11}+x_{12}-x_{13} \qquad (5)
\end{aligned}$$

The random noise component which has small correlation in the horizontal and vertical directions (for example, a white noise is flat in its frequency characteristic) is substantially evenly distributed to the respective data y_{00} to y_{03} and y_{10} to y_{13} of formula (5). On the other hand, the motion component of the output video signal has a specific frequency characteristic. Accordingly, the motion components subjected to the Hadamard transformation are mainly found in certain signal components (one component to four components) among the components y_{00} to y_{03} and y_{10} to y_{13} of formula (5).

Thereafter, the orthogonally transformed data y_{00} to y_{03} and y_{10} to y_{13} are output into the nonlinear processor **15** so as to extract noise components from the data. Figure **6A** shows the input/output characteristic of the nonlinear processor **15**. As shown in Figure **6A**, the output from the nonlinear processor **15** is maximum when the absolute value of the signal component $|y_{ij}|$ is a predetermined value A, while the output is zero when the absolute of the signal component$|y_{ij}|$ is equal to or more than the predetermined threshold 2A. The latter corresponds to the case where, when the input is equal to or more than the threshold 2A, the frame differential signal **S15** is judged as a motion component signal and therefore no noise signal is extracted. Hereinafter, the value A is referred to as the threshold for the nonlinear processor **15**.

The input/output characteristic of the nonlinear processor **15** may be set as shown in Figures **6B** to **6D**. It is also possible to determine an appropriate input/output characteristic by simulation, or depending on the type of the input video signal.

The threshold A of the nonlinear processor **15** is determined by the first control portion **31** based on the motion amount included in the input video signal **S11** determined by the motion amount determination portion **30**. Thus, how the motion amount determination portion **30** determines the motion amount is an important point of the present invention. The detailed configurations and operations of the motion amount determination portion **30**, the first control portion **31**, and the second control portion **32** will be described in the respective examples.

A signal component y'_{ij} corresponding to the signal component y_{ij} is output from the nonlinear processor **15**. The orthogonal inverse transformer **16** conducts on each component y'_{ij} the (4 x 2)th order Hadamard inverse transformation as expressed by formula (6):

$$\begin{aligned}
x'_{00} &= (y'_{00}+y'_{01}+y'_{02}+y'_{03}+y'_{10}+y'_{11}+y'_{12}+y'_{13}/8 \\
x'_{01} &= (y'_{00}-y'_{01}+y'_{02}-y'_{03}+y'_{10}-y'_{11}+y'_{12}-y'_{13}/8 \\
x'_{02} &= (y'_{00}+y'_{01}-y'_{02}-y'_{03}+y'_{10}+y'_{11}-y'_{12}-y'_{13}/8 \\
x'_{03} &= (y'_{00}-y'_{01}-y'_{02}+y'_{03}+y'_{10}-y'_{11}-y'_{12}+y'_{13}/8
\end{aligned}$$

$$x'_{10} = (y'_{00} + y'_{01} + y'_{02} + y'_{03} - y'_{10} - y'_{11} - y'_{12} - y'_{13}/8$$
$$x'_{11} = (y'_{00} - y'_{01} + y'_{02} - y'_{03} - y'_{10} + y'_{11} - y'_{12} + y'_{13}/8$$
$$x'_{12} = (y'_{00} + y'_{01} - y'_{02} - y'_{03} - y'_{10} - y'_{11} + y'_{12} + y'_{13}/8$$
$$x'_{13} = (y'_{00} - y'_{01} - y'_{02} + y'_{03} - y'_{10} + y'_{11} + y'_{12} - y'_{13}/8 \quad (6)$$

wherein x'_{ij} represents the signal component output from the orthogonal inverse transformer **16**. As will be easily observed, the Hadamard inverse transformation formula (6) has the same form as the Hadamard transformation formula (5) except for the existence of the coefficient 1/8. The pixel block after the Hadamard inverse transformation is shown in Figure **7**.

The pixel block of 4 x 2 data subjected to the Hadamard inverse transformation are output from the orthogonal inverse transformer **16** every sample timing T. As shown in Figure **8**, in the horizontal direction, the data x'_{00} at a time $t = t_0$, the data x'_{01} at a time $t = t_0 - T$ (1T behind the time t_0), the data x'_{02} at a time $t = t_0 - 2T$ (2T behind the time t_0), and the data x'_{03} at a time $t = t_0 -3T$ (3T behind the time t_0) are on the physically identical position on the screen. Likewise, in the vertical direction, the data x'_{00} at a time $t = t_0$, the data x'_{10} at a time $t = t_0 - t_h$ (1 line period t_h behind the time t_0), the data x'_{11} at a time $t = t_0 - t_h - T$ ((t_h + T) behind the time t_0), the data x'_{12} at a time $t = t_0 - t_h - 2T$ ((t_h + 2T) behind the time t_0), and the data x'_{13} at a time $t = t_0 - t_h - 3T$ ((t_h + 3T) behind the time t_0) are on the physically identical position on the screen. In other words, eight different outputs of orthogonally inverse-transformed data in the horizontal and vertical directions are obtained for one pixel position. The horizontal/vertical averaging portion **17** averages these eight outputs for one pixel position. By this averaging operation, ringing of horizontal and vertical motion components can be minimized.

Then, in the attenuator **18**, the output from the horizontal/vertical averaging portion **17** is multiplied by a feedback coefficient a ($0 \leq a < 1$). The feedback coefficient a is determined by the second control portion 32 based on the motion amount determined by the motion amount determination portion **30**. The detailed configurations and operations of the motion amount determination portion **30** and the second control portion **32** will be described in the respective examples.

Finally, the second subtracter **19** subtracts the attenuated noise signal **S12** output from the attenuator **18** from the input video signal **S11**, so as to obtain the output video signal **S13** with reduced noise. The thus noise-reduced video signal **S13** is output from the output terminal **21**.

Hereinbelow, Examples 1 to 4 will be described centering the motion amount determination portion **30**, the first control portion **31**, and the second control portion **32**.

Example 1

Figure **9** shows the configuration of the motion amount determination portion **30** of the first example according to the present invention. In example 1, the average of the absolute values of the data x_{00} to x_{03} and x_{10} to x_{13} in the 4 x 2 pixel block is used as the motion amount.

Referring to Figure **9**, the motion amount determination portion **30** includes absolute value circuits **301-1** to **301-k** (k = m x n, m = the number of samples in the horizontal direction in a pixel block, n = the number of lines in the vertical direction in the pixel block) and an average value calculator **302**. The k absolute value circuits **301-1** to **301-k** are connected to the serial/parallel converter **13**. The average value calculator **302** receives outputs from the absolute value circuits **301-1** to **301-k** and calculates the average of the outputs.

Figure **10** shows an exemplified configuration of the average value calculator **302**. Referring to Figure **10**, the reference numeral **10001** denotes an adder, and the reference numeral **10002** denotes a circuit for multiplying the output from the adder **10001** by 1/8.

The operation of the adaptive control portion **20** of the noise reducer of Example 1 with the above configuration will be described.

The motion amount determination portion **30** receives the data x_{00} to x_{03} and x_{10} to x_{13} of the pixel block output from the serial/parallel converter **13**. In the motion amount determination portion **30**, the absolute values of the respective data x_{00} to x_{03} and x_{10} to x_{13} are calculated by the absolute value circuits **301-1** to **301-k** (k = 8 in this example), and the average of these absolute values is calculated by the average calculator **302**. The first control portion **31** shown in Figure **2** controls the threshold A for the nonlinear processor **15** based on the output from the average calculator **302** (i.e., the average of the absolute values of the 4 x 2 data of the pixel block). The second control portion **32** shown in Figure **2** controls the feedback coefficient a for the attenuator **18** based on the output from the average calculator **302**.

Figures **11** and **12** are examples of the control characteristics of the first and second control portions **31** and **32**, respectively. As is apparent from Figures **11** and **12**, when the output from the average calculator **302** (i.e., the motion amount of the video signal) is large, the first and second control portions **31** and **32** judge the frame differential signal **S15** as the motion component and lowers the threshold A and the feedback coefficient a so as to reduce the feedback amount of the noise signal **S12**. By this adjustment, the motion component is prevented from being subtracted from the video signal, and thus deterioration in the quality of the motion picture portion is prevented. On the contrary, when the output from the average calculator **302** (i.e., the motion amount of the video signal) is small, the first and second control portions **31** and **32** judge the frame differential signal **S15** as the noise component and raise the threshold A and the feedback coefficient a so as to increase the feedback amount of the noise signal **S12**. By this adjustment, noise in the portion of small motion and the static picture portion can be effectively reduced.

Thus, according to the noise reducer of this example, where the motion amount determination portion **30** is composed of the absolute value circuits **301-1** to **301-k** and the average calculator **302**, the deterioration in the quality of the motion picture portion can be prevented and noise in the static picture portion and the small motion can be effectively reduced.

Example 2

Figure **13** shows the configuration of the motion amount determination portion **30** of the second example according to the present invention. In Example 2, the degree of variation (dispersion parameter) of the absolute values $|y_{ij}|$ of the data y_{ij} is used as the motion amount. As described above, the data y_{ij} is obtained by the Hadamard transformation of the pixel block of 4 x 2 data x_{ij} shown in Figure **4**.

Referring to Figure **13**, the motion amount determination portion **30** includes k absolute value circuits **401-1** to **401-k** and a dispersion parameter calculator **402**. Two examples of the dispersion parameter calculator **402** are shown in Figures **14** and **15**.

One example of the dispersion parameter calculator **402** shown in Figure **14** includes an average calculator **20001** connected to the absolute value circuits **401-1** to **401-k**, k subtracters **20002-1** to **20002-k** connected to the absolute value circuits **401-1** to **401-k** and the average calculator **20001**, k absolute value circuits **20003-1** to **20003-k** connected to the k subtracters **20002-1** to **20002-k**, and an adder **20004** connected to the absolute value circuits **20003-1** to **20003-k**. The average calculator **20001** has the same configuration as the average calculator **302** shown in Figure **10**. The dispersion parameter calculator **402** of Figure **14** calculates a dispersion parameter σ_1 expressed by formula (7):

$$\sigma_1 = \sum_{\substack{0 \le i \le n \\ 0 \le j \le m}} \left| |y_{ij}| - y_{ave} \right| \quad \cdots\cdots (7)$$

wherein,

$$y_{ave} = \left(\sum_{\substack{0 \le i \le n \\ 0 \le j \le m}} |y_{ij}| \right) \Big/ (m \times n) \quad \cdots\cdots (8)$$

The other example of the dispersion parameter calculator **402** shown in Figure **15** is different from that shown in Figure **14** in that multipliers **30001-1** to **30001-k** are disposed, in place of the absolute value circuits **20003-1** to **20003-k**, so that each of the outputs from the subtracters **20002-1** to **20002-k** is multiplied by itself before being input into the adder **20004**. The dispersion parameter calculator **402** of Figure **15** calculates a dispersion parameter σ_2 expressed by formula (9):

$$\sigma_2 = \sum_{\substack{0 \leq i \leq n \\ 0 \leq j \leq m}} (|y_{ij}| - y_{ave})^2 \quad \cdots\cdots (9)$$

The dispersion parameter σ_2 corresponds to the power sum of the frame differential signal **S15** and is considered to indicate the motion amount more precisely. However, the circuit configuration of the dispersion parameter calculator **402** of Figure **15** is more complicated than that of Figure **14**.

Figures **16A** and **16B** show the distributions of the absolute values of the orthogonally transformed data y_{ij} (eight components) in the case where the frame differential signal **S15** is the motion component signal and the noise component signal, respectively. In Figure **16A** which shows the case of the motion component signal, the output from the orthogonal transformer **14** largely varies with the absolute values $|y_{ij}|$ of certain components being larger than the remaining components. Accordingly, the dispersion parameter is large. In Figure **16B** which shows the case of the noise component signal, the absolute values $|y_{ij}|$ of all the components are substantially the same. Accordingly, since the degree of variation is small, the dispersion parameter is small. As a result, whether the output from the first subtracter **12** is the motion component signal or the noise component signal can be identified by the level of the dispersion parameter.

The operation of the adaptive control portion **20** of the noise reducer of Example 2 will be described.

Referring to Figure **13**, the absolute value circuits **401-1** to **401-k** calculate the absolute values of k data y_{ij} output from the orthogonal transformer **14**. The dispersion parameter calculator **402** calculates the sum of the absolute values of the deviations of the k absolute values $|y_{ij}|$ from the average (Figure **14**), or the sum of the squares of the deviations of the k absolute values $|y_{ij}|$ from the average (Figure **15**).

The first control portion **31** controls the threshold A for the nonlinear processor **15** based on the output from the dispersion parameter calculator **402**. The second control portion **32** controls the feedback coefficient a for the attenuator **18** based on the output from the dispersion parameter calculator **402**.

Figures **17** and **18** are examples of the control characteristics of the first and second control portions **31** and **32** in Example 2, respectively. As is apparent from Figures **17** and **18**, when the output from the dispersion parameter calculator **402** (i.e., the motion amount of the video signal) is large, the first and second control portions **31** and **32** judge the frame differential signal **S15** as the motion component and lower the threshold A and the feedback coefficient a so as to reduce the feedback amount of the noise signal **S12**. By this adjustment, deterioration in the quality of the motion picture portion is prevented. On the contrary, when the output from the dispersion parameter calculator **402** (i.e., the motion amount of the video signal) is small, the first and second control portions **31** and **32** judge the frame differential signal **S15** as the noise component and raise the threshold A and the feedback coefficient a so as to increase the feedback amount of the noise signal **S12**. By this adjustment, noise in the picture portion with small motion and the static picture portion can be effectively reduced.

Thus, according to the noise reducer of this example, where the motion amount determination portion **30** is composed of the absolute value circuits **401-1** to **401-k** and the dispersion parameter calculator **402**, the deterioration in the quality of the motion picture portion can be prevented, and noise in the static picture portion and the picture portion with small motion can be effectively reduced.

Example 3

Figure **19** shows the configuration of the motion amount determination portion **30** of the third example according to the present invention. In Example 3, the absolute value $|y_{ij}|$ of the data y_{ij} output from the orthogonal transformer **14** are used as the motion amount.

Referring to Figure **19**, the motion amount determination portion **30** includes k absolute value circuits **501-1** to **501-k**.

When the Hadamard transformation is used for the orthogonal transformation, the Hadamard transformed data y_{ij}, y_{00} includes a comparatively large motion component, y_{02} and y_{03} includes a comparatively large horizontal edge component, y_{10} includes a comparatively large vertical edge component, and y_{12} and y_{13} include a comparatively large slant edge component. The absolute values of the six components $|y_{00}|$, $|y_{02}|$, $|y_{03}|$, $|y_{10}|$, $|y_{12}|$, and $|y_{13}|$ among the eight components of the (4 x 2)th order Hadamard transformed outputs, for example, are used as the motion amount. Herein, as an example, the first control portion **31** controls the threshold A for the nonlinear processor **15** by using the absolute value of the motion component $|y_{00}|$, while the second control portion **32** controls the feedback coefficient a for the attenuator **18** by using the maximum of the absolute values of the edge components $|y_{02}|$, $|y_{03}|$, $|y_{10}|$, $|y_{12}|$, and $|y_{13}|$.

Figures **20** and **21** are examples of the control characteristics of the first and second control portions **31** and **32** in Example 3, respectively. As is apparent from Figures **20** and **21**, the first control portion **31** lowers the threshold A when $|y_{00}|$ is large, and the second control portion **32** lowers the feedback coefficient a when the maximum of $|y_{02}|$, $|y_{03}|$, $|y_{10}|$, $|y_{12}|$, and $|y_{13}|$ is large, so as to reduce the feedback amount. By this adjustment, deterioration in the quality of the motion picture portion is prevented. On the contrary, when $|y_{00}|$ and the maximum of $|y_{02}|$, $|y_{03}|$, $|y_{10}|$, $|y_{12}|$, and $|y_{13}|$ are small, the threshold A and the feedback coefficient a are raised so as to increase the feedback amount. By this adjustment, noise in the picture portion with small motion and the static picture portion can be effectively reduced.

Thus, according to the noise reducer of this example, where the motion amount determination portion **30** is composed of the absolute value circuits **501-1** to **501-k**, the deterioration in the quality of the motion picture portion can be prevented, and noise in the static picture portion and the picture portion with small motion can be effectively reduced. Further, the circuit configuration of the motion amount determination portion **30** of Example 3 can be simpler than those of Examples 1, 2, and 4.

In Example 3, only $|y_{00}|$ was used for the control of the threshold A for the nonlinear processor 15. However, any other Hadamard transformed component other than y_{00} may be used. Alternatively, the maximum of the absolute values of n components (n = natural number equal to or less than 8) among the eight Hadamard transformed components may be used. For the control of the feedback coefficient a for the attenuator **18**, the maximum of the absolute values of n components (n = natural number equal to or less than 8) other than six components used in Example 3 among the eight Hadamard transformed components may also be used.

Example 4

Figure **22** shows the configuration of the motion amount determination portion **30** of the fourth example according to the present invention. In Example 4, the absolute values of the i components (i = natural number less than k) which have been subjected to an operation of removing isolated points (an isolated-point removal) and the absolute values of (k-i) components which have not been subjected to the isolated-point removal are used as the motion amount. In this example, one pixel block is composed of k = m sample(s) x n line(s) is used.

Referring to Figure **22**, the motion amount determination portion **30** includes i isolated-point removal portions **601-1** to **601-i** connected to the orthogonal transformer **14**, (k-i) delay circuits **602-1** to **602-(k-i)** connected to the orthogonal transformer **14**, and k absolute value circuits **603-1** to **603-k** connected to the isolated-point removal portions **601-1** to **601-i** and the delay circuits **602-1** to **602-(k-i)**. The delay time at the delay circuits **602-1** to **602-(k-i)** is the same as the time delayed at the isolated-point removal portions **601-1** to **601-i**. Hereinafter, the isolated-point removal portions **601-1** to **601-i** are collectively referred to as the isolated-point removal portion **601** unless this causes misunderstanding.

Figures **23**, **24**, and **25** show examples of the isolated-point removal portion **601**. The isolated-point removal portion **601** shown in Figure **23** includes a one-sample delay circuit **40001-1** connected to the orthogonal transformer **14**, another one-sample delay circuit **40001-2** connected to the one-sample delay circuit **40001-1**, and a selector **40002** connected to the orthogonal transformer **14** and the one-sample delay circuits **40001-1** and **40001-2**. The isolated-point removal portion **601** further includes a comparator **40003-1** connected to the one-sample delay circuits **40001-1** and **40001-2**, another comparator **40003-2** connected to the orthogonal transformer **14** and the one-sample delay circuit **40001-2**, yet another comparator **40003-3** connected to the orthogonal transformer **14** and the one-sample delay circuit **40001-1**, an exclusive OR (EXOR) gate **40004-1** connected to the comparators **40003-1** and **40003-2** and the selector **40002**; and another EXOR gate **40004-2** connected to the comparators **40003-2** and **40003-3** and the selector **40002**. The selector **40002** selects one of three inputs based on a control signal **P** or **Q** respectively supplied from the EXOR gates **40004-1** and **40004-2** and outputs the selected input. The output of the selector **40002** is connected to the corresponding absolute value circuits **603-1** to **603-k**.

The isolated-point removal portion **601** shown in Figure **24** is different from that of Figure **23** in that one-line delay circuits **40011-1** and **40011-2** are used in place of the one-sample delay circuits **40001-1** and **40001-2** in Figure **23**.

Likewise, the isolated-point removal portion **601** shown in Figure **25** is different from that of Figure **23** in that one-frame delay circuits **40021-1** and **40021-2** are used in place of the one-sample delay circuits **40001-1** and **40001-2** in Figure **23**.

The operation of the adaptive control portion **20** of the noise reducer of Example 4 with the above configuration will be described. In this example, the motion amount is determined by the absolute values of the i components subjected to the isolated-point removal and the absolute values of (k-i) components not subjected to the isolated-point removal. In this example, the case where k = 4 x 2 = 8 will be described.

First, the isolated-point removal will be described. Removal of an isolated point is performed by selecting a median of the adjacent three sample points. By this operation, it is possible to remove a sample point having an irregular value. In the case of the motion component signal including the edge components, the motion component is retained after the isolated-point removal, since a sample point of the motion component seldom has a singular value. In the case of noise, however, a sample point often has a singular value. Accordingly, such noise having a singular value can be removed by conducting an isolated-point removal. This isolated-point removal makes it possible to prevent such a singular value of a signal generated by noise from being mistaken as a motion component of the signal. As a result, a higher level of distinction between the noise and the motion component can be obtained, compared with the case where no isolated-point removal is conducted (see Example 3).

The three adjacent sample points for the isolated-point removal can be taken in the horizontal direction (samples), in the vertical direction (lines), or along the temporal axis (frames). The examples of the isolated-point removal portion **601** shown in Figures **23** to **25** respectively correspond to the horizontal direction, the vertical direction, and the temporal axis, respectively. The isolated-point removal will be described as follows using the isolated-point removal portion **601** of Figure **23**.

The component y_{00} among the Hadamard transformed data y_{00} to y_{03} and y_{10} to y_{13} output from the orthogonal transformer **14** is isolated-point removed by the isolated-point removal portion **601-1**. Referring to Figure **23**, the operation at the isolated-point removal portion **601-1** will be described. In the description, the present value of y_{00} is denoted by α, the value of y_{00} one sample behind is denoted by β, and the value of y_{00} two samples behind is denoted by γ. The comparators **40003-1**, **40003-2**, and **40003-3** output a flag 1 when the result of the subtraction between two inputs is positive or zero, and output a flag 0 when it is negative. The outputs from the comparators **40003-1**, **40003-2**, and **40003-3** are referred to as FL1, FL2, and FL3, respectively. The EXOR gate **40004-1** calculates the exclusive OR of FL1 and FL2, while the EXOR gate **40004-2** calculates the exclusive OR of FL2 and FL3. The outputs **P** and **Q** from the EXOR gates **40004-1** and **40004-2** are used as a control signal for the selector **40002**. Table 1 shows the values of FL1, FL2, and FL3, the values of the selector control signals **P** and **Q**, and the value (α, β, or γ) output from the selector **40002** in response to the selector control signals **P** and **Q** for six cases of the relationships among α, β, and γ. The selector **40002** is set so that β is output when P = 0 and Q = 0, α is output when P = 0 and Q = 1, and γ is output when P = 1 and Q = 0.

Table 1

Case	FL1	FL2	FL3	P	Q	Selector output
$\alpha > \beta > \gamma$	0	0	0	0	0	β
$\gamma > \beta > \alpha$	1	1	1			
$\beta > \alpha > \gamma$	0	0	1	0	1	α
$\gamma > \alpha > \beta$	1	1	0			
$\alpha > \gamma > \beta$	1	0	0	1	0	γ
$\beta > \gamma > \alpha$	0	1	1			

Then, the absolute value of the y_{00} subjected to the isolated-point removal (hereinafter, referred to as y_{00}med) is calculated by the absolute value circuit **603-1**. For the other seven components among the Hadamard transformed data other than the component y_{00} which have not been subjected to the isolated-point removal, the absolute values are calculated by the absolute value circuits **603-2** to **603-8**.

In this example, as in Example 3, six components $|y_{00}|$, $|y_{02}|$, $|y_{03}|$, $|y_{10}|$, $|y_{12}|$, and $|y_{13}|$ among the eight components of the (4 x 2)th order Hadamard transformed outputs, for example, are used for calculating the motion amount. Herein, as an example, the first control portion **31** controls the threshold A for the nonlinear processor **15** based on the absolute value $|y_{00}med|$, while the second control portion **32** controls the feedback coefficient a for the attenuator **18** by using the maximum of the components $|y_{02}|$, $|y_{03}|$, $|y_{10}|$, $|y_{12}|$, and $|y_{13}|$.

Figures **26** and **27** are examples of the control characteristics of the first and second control portions **31** and **32** in Example 4, respectively. As is apparent from Figures **26** and **27**, the first control portion **31** lowers the threshold A when $|y_{00}med|$ is large, and the second control portion **32** lowers the feedback coefficient a when the maximum of $|y_{02}|$, $|y_{03}|$, $|y_{10}|$, $|y_{12}|$, and $|y_{13}|$ is large, so as to reduce the feedback amount. By this adjustment, deterioration in the quality of the motion picture portion is prevented. On the contrary, when $|y_{00}med|$ and the maximum of $|y_{02}|$, $|y_{03}|$, $|y_{10}|$, $|y_{12}|$, and $|y_{13}|$ are small, the threshold A and the feedback coefficient a are made large so as to increase the feedback amount. By this adjustment, noise in the picture portion with small motion and the static picture portion can be effectively reduced.

Thus, according to the noise reducer of this example, where the motion amount determination portion **30** is composed of the isolated-point removal portions **601-1** to **601-i**, the delay circuits **602-1** to **602-(k-i)**, and the absolute value circuits **603-1** to **603-k**, noise having a singular value of a sample point will not be mistaken as the motion component. As a result, deterioration in the quality of the motion picture portion can be prevented, and noise in the still picture portion and the picture portion with small motion can be effectively reduced.

In Example 4, only $|y_{00}med|$ was used for the control of the threshold A for the nonlinear processor **15**. Any one of the Hadamard transformed components y_{ij} other than the component y_{00} may also be used for the isolated-point removal. Alternatively, n components (n = natural number equal to or less than 8) among the eight Hadamard transformed components may be subjected to isolated-point removal so as to use the maximum of the absolutes of the n components. For the control of the feedback coefficient a for the attenuator **18**, n components (n = natural number equal to or less than 8) other than the six components used in this example among the eight Hadamard transformed components may be subjected to the isolated-point removal so as to use the maximum of the absolutes of the components.

The control of the threshold A and the feedback coefficient a is also possible by combining some characteristics of the Hadamard transformed components. For example, for the control of the threshold A, the component y_{00} which tends to have a large motion component may be used to obtain the motion amount by conducting the isolated-point removal and calculating the absolute value as described above. For the feedback coefficient a, on the other hand, a horizontal edge and a vertical edge are detected by using the horizontal edge components y_{01}, y_{02}, and y_{03}, respectively, so as to obtain an edge component for the signal. The feedback coefficient a can be controlled by the edge components.

In Example 4, the motion amount determination portion **30** with the isolated-point removal portion **601** of Figure **23** was described. Similar results will be obtained by using the isolated-point removal portion **601** of Figure **24** or **25** where the direction of the adjacent sample points taken for the isolated-point removal is different. These examples of the isolated-point removal portion **601** may be combined so as to effect the isolated-point removal in a plurality of directions.

Example 5

Figure **28** shows a noise reducer **300** of the fifth example according to the present invention. In Figure **28**, components having the same configuration and the operation as those of the noise reducer **200** of Figure **2** are denoted by the same reference numerals. The configuration of the motion amount determination portion **30** may be that shown in any of Examples 1 to 4. The noise reducer **300** of this example additionally includes a noise amplitude detection portion **44**. The noise amplitude detection portion **44** detects the amplitude of noise included in the frame differential signal **S15** and outputs a detection signal. This detection signal is used as a parameter for controlling the first and second control portions **31** and **32** together with the output from the motion amount determination portion **30**.

As shown in Figure **28**, the noise amplitude detection portion **44** is connected to the first subtracter **12**, the first control portion **31**, and the second control portion **32**. Figure **29** shows the configuration of the noise amplitude detection portion **44**. Referring to Figure **29**, the noise amplitude detection portion **44** includes a high-pass filter **701** connected to the first subtracter **12**, an absolute value circuit **702** connected to the high-pass filter **701**, and a smoothing circuit **703** connected to the absolute value circuit **702**. The output of the smoothing circuit **703** is connected to the first and second control portions **31** and **32**. The smoothing circuit **703** can be implemented with a low-pass filter, for example.

The operation of the noise reducer **300** of Example 5 will be described. The operations of the components of the noise reducer **300** other than the noise amplitude detection portion **44**, the first control portion **31**, and the second control portion **32** are the same as those of the noise reducer **200** described in the above examples.

Referring to Figures **29** and **30A** to **30D**, the operation of the noise amplitude detection portion **44** will be first described. Figures **30A** to **30D** show waveforms of a signal to be processed by the noise amplitude detection portion **44** of Figure **29**. First, the high-pass filter **701** of the noise amplitude detection portion **44** extracts a high-frequency noise component from the output from the first subtracter **12** (i.e., the frame differential signal **S15**). As shown in Figure **30A**, a motion component S_m included in the frame differential signal **S15** generally varies slowly, while a noise component **N** varies abruptly. Accordingly, it is possible to extract only the noise component **N** by high-pass filtering (see Figure **30B**). The absolute value circuit **702** calculates the absolute value of the noise component **N** extracted by the high-pass filter **701** (see Figure **30C**). The output from the absolute value circuit **702** is then passed through the smoothing circuit **703** so as to obtain a signal with a waveform as shown in Figure **30D**. The output signal from the smoothing circuit **703** is an output of the noise amplitude detection portion **44** having an amplitude value of **h**.

Figures **31** and **32** show examples of the control characteristics of the first and second control portions **31** and **32** in Example 5, respectively. In the first and second control portions **31** and **32**, when the noise amplitude detection value **h** is large, the respective characteristic curves are shifted to raise the threshold A and the feedback coefficient a, so as to increase the feedback amount of the noise signal **S12**. Thus, the noise reduction effect enhances. On the contrary, when the noise amplitude detection value **h** is small, the respective characteristic curves are shifted to lower the threshold A and the feedback coefficient a, so as to reduce the feedback amount of the noise signal **S12**. Thus, the noise reduction effect lowers. In this way, the feedback amount of the noise signal **S12** is adjusted according to the amplitude of the noise included in the input video signal **S11**.

As described above, according to the noise reducer **300** of this example, where the noise amplitude detection portion **44** is additionally provided, the feedback amount is adjusted according to the amplitude of the noise included in the input video signal, in addition to the adaptive control described in Example 1 to 4. By this adjustment, the deterioration in the quality of the motion picture portion can be prevented, and noise in the still picture portion and the picture portion with small motion can be reduced more effectively.

Example 6

Figure **33** shows a noise reducer **400** of the sixth example according to the present invention. In Figure **33**, components having the same configuration and the operation as those of the noise reducer **200** of Figure **2** are denoted by the same reference numerals. In this example, as in Example 5, the configuration of the motion amount determination portion **30** may be that shown in any of Examples 1 to 4. The noise reducer **400** of this example additionally includes a signal amplitude detection portion **45**. The signal amplitude detection portion **45** detects the amplitude of the input video signal **S11**, and outputs a detection signal. This detection signal is used as a parameter for controlling the first and second control portions **31** and **32** together with the output from the motion amount determination portion **30**.

As shown in Figure **33**, the signal amplitude detection portion **45** is connected to the input terminal **10**, the first control portion **31**, and the second control portion **32**. Figure **34** shows the configuration of the signal amplitude detection portion **45**. Referring to Figure **34**, the signal amplitude detection portion **45** includes a serial/parallel converter **801** connected to the input terminal **10**, a maximum value detector **802** and a minimum value detector **803** connected to the serial/parallel converter **801**, and a subtracter **804** connected to the maximum value detector **802** and the minimum value detector **803**. The output of the subtracter **804** is connected to the first and second control portions **31** and **32**. The configuration of the serial/parallel converter **801** is the same as that of the serial/parallel converter **13** shown in Figure **3**.

The operation of the noise reducer **400** of Example 6 will be described. The operations of the components of the noise reducer **400** other than the signal amplitude detection portion **45**, the first control portion **31**, and the second control portion **32** are the same as those of the noise reducer **200** described in Examples 1 to 4.

Referring to Figure **34**, the operation of the signal amplitude detection portion **45** will be described. The serial/parallel converter **801** converts the input video signal **S11** into temporally parallel data of a pixel block. The maximum value detector **802** detects the maximum value of the data of the pixel block, while the minimum value detector **803** detects the minimum value of the data of the pixel block. The subtracter **804** subtracts the output from the minimum value detector **803** from the output from the maximum value detector **802**. The output from the subtracter **804** which indicates the amplitude value of the input video signal **S11** is supplied to the first control portion **31** and the second control portion **32**. This amplitude value represents a characteristic of the pattern of the picture displayed by the input video signal **S11**. For example, in the case where the input video signal **S11** is a luminance signal, a large amplitude value indicates that a pattern with a great variation in the luminance (a gravel road, for example) is displayed, while a small amplitude value indicates that a smooth pattern with a small variation in the luminance (a water surface, for example) is displayed.

Figures **35** and **36** are examples of the control characteristics of the first and second control portions **31** and **32** in Example 6, respectively. When the output from the signal amplitude detection portion **45** is large, the first and second control portions **31** and **32** judge that an image of a largely varying pattern (fine pattern) is displayed, and shift the respective characteristic curves to lower the threshold A and the feedback coefficient a, so as to reduce the feedback amount of the noise signal **S12**. Thus, deterioration in the quality of an image with a fine pattern is suppressed. On the contrary, when the output from the signal amplitude detection portion **45** is small, the first and second control portions **31** and **32** judge that an image with a smooth pattern is displayed, and shift the respective characteristic curves to raise the threshold A and the feedback coefficient a, so as to increase the feedback amount of the noise signal **S12**. Thus, the noise reduction effect is enhanced. In this way, the feedback amount of the noise signal **S12** is adjusted according to the characteristic of the pattern of the image displayed.

As described above, according to the noise reducer **400** of this example, where the signal amplitude detection portion **45** is additionally provided, the feedback amount is adjusted according to the pattern of the input video signal, in addition to the adaptive control described in Examples 1 to 4. This adjustment makes it possible to prevent deterioration in the quality of an image with a fine pattern having a great variation in the motion picture portion, while reducing noise in the still picture portion and the picture portion with small motion more effectively.

Example 7

Figure **37** shows a noise reducer **500** of the seventh example according to the present invention. In Figure **37**, components having the same configuration and operation as those of the noise reducer **200** of Figure **2** are denoted by the same reference numerals. In this example, as in Examples 5 and 6, the configuration of the motion amount determination portion **30** may be that shown in any of Examples 1 to 4. The noise reducer **500** of this example additionally includes a signal level detection portion **46**. The signal level detection portion **46** detects the level of the input video signal **S11**, and outputs a detection signal. This detection signal is used as a parameter for controlling the first and second control portions **31** and **32** together with the output from the motion amount determination portion **30**.

As shown in Figure **37**, the signal level detection portion **46** is connected to the input terminal **10**, the first control portion **31**, and the second control portion **32**. Figure **38** shows the configuration of the signal level detection portion **46**. Referring to Figure **38**, the signal level detection portion **46** includes a serial/parallel converter **901** connected to the input terminal **10**, and an average calculator **902** connected to the serial/parallel converter **901**. The output of the average calculator **902** is connected to the first and second control portions **31** and **32**. The configuration of the serial/parallel converter **901** is the same as that of the serial/parallel converter **13** of Figure **3**.

The operation of the noise reducer **500** of Example 7 will be described. The operations of the components of the noise reducer **500** other than the signal level detection portion **46**, the first control portion **31**, and the second control portion **32** are the same as those of the noise reducer **200** described in Examples 1 to 4.

Referring to Figure **38**, the operation of the signal level detection portion **46** will be described. The serial/parallel converter **901** converts the input video signal **S11** into temporally parallel data of a pixel block. The average calculator **902** calculates the average of the data of the pixel block. The output from the average calculator **902** is supplied to the first control portion **31** and the second control portion **32**. This output from the average value calculator **902** represents an average signal level of the input video signal **S11**. For example, in the case where the input video signal **S11** is a luminance signal, a large value of the average indicates a high luminance (i.e., the image is bright). On the contrary, a small value of the average indicates a low luminance (i.e., the image is dark).

Figures **39** and **40** are examples of the control characteristics of the first and second control portions **31** and **32** in Example 7, respectively. When the output from the signal level detection portion **46** is large, the first and second control portions **31** and **32** judge that a high-luminance (bright) video signal is input, and shift the respective characteristic curves to lower the threshold A and the feedback coefficient a, so as to reduce the feedback amount of the noise signal **S12**. Thus, the noise removal effect on the high-luminance image is suppressed. On the contrary, when the output from the signal level detection portion **46** is small, the first and second control portions **31** and **32** judge that a low-luminance (dark) video signal is input, and shift the respective characteristic curves to raise the threshold A and the feedback coefficient a, so as to increase the feedback amount of the noise signal **S12**. Thus, the noise reduction effect on the low-luminance image is enhanced. In this way, the feedback amount of the noise signal **S12** is adjusted according to the brightness of the image displayed by the input video signal **S11**.

As described above, according to the noise reducer **500** of this example, where the signal level detection portion **46** is additionally disposed, the feedback amount is adjusted according to the luminance of the input video signal, in addition to the adaptive control described in Examples 1 to 4. This adjustment makes it possible to prevent deterioration in the quality of a bright image in the motion picture portion, while reducing noise in the still picture portion and the picture portion with small motion more effectively.

Example 8

Figure **41** shows a noise reducer **600** of the eighth example according to the present invention. In Figure **41**, components having the same configuration and operation as those of the noise reducer **200** of Figure **2** are denoted by the same reference numerals. In this example, as in Examples 5 to 7, the configuration of the motion amount determination portion **30** may be that shown in any of Examples 1 to 4. The noise reducer **500** of this example additionally includes a signal identification portion **47**. The signal identification portion **47** identifies the type of input video signal **S11**, and outputs an identification code. Alternatively, the type of input video signal **S11** is identified by a signal identification code input from an external identification code input terminal **48**. This identification code is used as a parameter for controlling the first and second control portions **31** and **32** together with the output from the motion amount determination portion **30**.

As shown in Figure **41**, the signal identification portion **47** is connected to the input terminal **10**, the first control portion **31**, and the second control portion **32**. Alternatively, the external identification code input terminal **48** is connected to the first control portion **31** and the second control portion **32**.

The operation of the noise reducer **600** of Example 8 will be described. The operations of the components of the noise reducer **600** other than the signal identification portion **47**, the first control portion **31**, and the second control portion **32** are the same as those of the noise reducer **200** described in Examples 1 to 4.

The operation of the signal identification portion **47** will be first described. The video signal **S11** input into the input terminal **10** may be an NTSC signal or a PAL signal. Otherwise, a plurality of different video signals (such as a color signal and a luminance signal) may be input into the input terminal **10** in one horizontal period. The signal identification portion **47** identifies the type of the input video signal and outputs the identification code corresponding to the type of input video signal. For example, when an NTSC signal is input as the video signal, '0' is output as the identification code. When an PAL signal is input, '1' is output as the identification code. In the case where such an identification code is supplied externally, the identification code is input through the external identification code input terminal **48**.

Figures **42** and **43** are examples of the control characteristics of the first and second control portions **31** and **32** in Example 8, respectively. When the identification code output from the signal identification portion **47** is '1', the first and second control portions **31** and **32** shift the respective characteristic curves to lower the threshold A and the feedback coefficient a, so as to reduce the feedback amount of the noise signal **S12**. Thus, the noise removal effect is suppressed. On the contrary, when the identification code is '0', the first and second control portions **31** and **32** shift the respective characteristic curves to raise the threshold A and the feedback coefficient a, so as to increase the feedback amount of the noise signal **S12**. Thus, the noise reduction effect is enhanced. In this way, the feedback amount of the noise signal **S12** is adjusted according to the type of input video signal **S11**.

As described above, according to the noise reducer **600** of this example, where the signal identification portion **47** or the external identification code input terminal **48** is additionally provided, the feedback amount is adjusted according to the type of input video signal, in addition to the adaptive control described in Examples 1 to 4. This adjustment makes it possible to prevent deterioration in the quality of an image in the motion picture portion, while reducing noise in the still picture portion and the picture portion with small motion more effectively.

Example 9

Figures **44** and **45** show noise reducers **700** and **800** of the ninth example according to the present invention. In Figure **44**, components having the same configuration and operation as those of the noise reducer **100** of Figure **1** are denoted by the same reference numerals. Figure **45** shows the adaptive control portion **20** of Figure **44** more specifically. In Figure **45**, components having the same configuration and operation as those of the noise reducer **200** of Figure **2** are denoted by the same reference numerals. The noise reducers **700** and **800** of this example include a horizontal averaging portion **23** in place of the horizontal/vertical averaging portion **17** of the noise reducers **100** and **200**, and additionally includes a line delay circuit **24**.

The noise reducer of Example 9 will be described with reference to Figure **45** showing the noise reducer **800**. In the noise reducer **800**, the horizontal averaging portion **23** averages the output from the orthogonal inverse transformer **16** only in the horizontal direction. Also, a portion of the output from the horizontal averaging portion **23** is returned to the serial/parallel converter **13** through the line delay circuit **24**.

Figure **46** shows the configuration of the horizontal averaging portion **23**, where the function of the vertical averaging is not included, as compared with the configuration of the horizontal/vertical averaging portion **17**.

The operation of the noise reducer **800** with the above configuration will be described with reference to Figure **45**. In this example, only the points different from the operation of the noise reducer **200** of Figure **2** will be described.

The horizontal averaging portion **23** averages the data x_{ij} output from the orthogonal inverse transformer **16** in a horizontal direction. The data x_{ij} to be averaged are those at different sample points of different pixel blocks in the horizontal direction, but corresponds to a physically identical pixel position of the image. For example, when the case described with reference to Figure **8** is used, four different data (orthogonally inverse-transformed data) in the horizontal direction corresponding to an identical pixel position are averaged. Hereinbelow, the case of the pixel block of 4 x 2 data will be described with reference to Figure **47**.

The data obtained by averaging the four data in the upper portion (row) of the pixel block in the horizontal direction is referred to as x''_{00}, and the data obtained by averaging the four data in the lower portion (row) of the pixel block in the horizontal direction is referred to as x''_{10}. Sequentially, four samplings (at a sampling period T) provide four horizontally different sampling points corresponding to an identical pixel position on the screen (each sampling point belongs to a different pixel block). The four sampling points are averaged to obtain a horizontal average value corresponding to one pixel position (refer to Figure **8**). The above operation is conducted for the four pixel positions corresponding to the upper portion of the pixel block so as to obtain four horizontally averaged data x''_{00}. Likewise, the operation is conducted for the four pixel positions corresponding to the lower portion of the pixel block so as to obtain four horizontally averaged data x''_{10}. The four data x''_{10} sampled at different sampling times are delayed by the line delay circuit **24** and input into the serial/parallel converter **13**. The serial/parallel converter **13** outputs the four data x''_{10} as the data x_{00} to x_{03} in the upper portion of the "next" pixel block. The "next" block is located just below an "original" pixel block by one line. More specifically, the data x''_{10} obtained at a certain sampling time ($t = t_0 - 3T$) is used as the data x_{00} of the "next" pixel block. The data x''_{10} obtained at the second sampling time ($t = t_0 - 2T$) is used as the data x_{01} of the "next" pixel block. The data x''_{10} obtained at the third sampling time ($t = t_0 - T$) is used as the data x_{02} of the "next" pixel block. And, finally, the data x''_{10} obtained at the fourth sampling time ($t = t_0$) is used as the data x_{03} of the "next" pixel block. In this way, the "next" pixel block located just below by one line is produced by using the thus-obtained x_{00} to x_{03} and the data x_{10} and x_{13} obtained from the frame differential signal of the next line. This operation is shown in Figure **47**. The data in the upper portion of the "next" pixel block have a much lower probability of including a motion component in the data, since they are those once extracted as noise. Accordingly, the image quality of the motion picture portion is less deteriorated compared with the case where the upper portion of the pixel block is produced directly by the frame differential signal.

The horizontally averaged data x''_{00} in the upper portion of the original pixel block is output to the attenuator **18**, where they are multiplied by the feedback coefficient a. The subsequent operation is the same as that described with reference to the noise reducer **200** of Figure **2**, and thus the description thereof is omitted here.

Thus, according to this example, the horizontal/vertical averaging portion **17** of the noise reducer **200** is replaced with the horizontal averaging portion **23**, and part of the output from the horizontal averaging portion **23** is returned and input into the serial/parallel converter **13** through the line delay circuit **24**. This configuration reduces the probability of including a motion component in the noise signal **S12**. This makes it possible to prevent deterioration in the quality of an image in the motion picture portion, while reducing noise in the still picture portion and the picture portion with small motion more effectively.

Though, in the above examples, the pixel block including m = 4 samples in the horizontal direction and n = 2 lines in the vertical direction was adopted, m and n can be other natural numbers. The pixels may be sampled every r samples and every s lines (r, s = natural numbers) in the pixel block. The input/output characteristic of the nonlinear processor **15** is not limited to that shown in Figure **6A**, but a limiter characteristic where a fixed value is output when the input exceeds a predetermined value (Figure **6B**), a characteristic having a trapezoid shape (Figure **6C**) or a curved shape (Figure **6D**), instead of the triangle shape as in Figure **6A** may also be adopted. The control characteristics of the first and second control portions **31** and **32** may be curved instead of the polygonal line in the above examples.

Various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein, but rather that the claims be broadly construed.

Claims

1. A noise reducer for outputting a noise-reduced signal by extracting noise included in an input video signal so as to produce a noise signal and by subtracting the noise signal from the input video signal, the noise reducer comprising:

a signal processing portion including:

delay means for delaying the noise-reduced signal by a predetermined time period so as to output a delayed signal;

first subtraction means for subtracting the delayed signal from the input video signal so as to output a differential signal;

transformation means for receiving the differential signal and conducting orthogonal transformation on the differential signal, each of pixel blocks of the differential signal being transformed as a unit, so as to output an orthogonally transformed signal;

processing means for receiving the orthogonally transformed signal and conducting nonlinear processing on the orthogonally transformed signal based on a predetermined threshold so as to output a nonlinear processed signal;

inverse transformation means for receiving the nonlinear processed signal and conducting an inverse transformation of the orthogonal transformation on the nonlinear processed signal so as to output an inversely transformed signal; and

attenuation means for receiving the inversely transformed signal and attenuating the inversely transformed signal by a predetermined coefficient so as to output the noise signal;

second subtraction means for subtracting the noise signal from the input video signal so as to output a noise-reduced signal; and

adaptive control means for controlling at least one of the predetermined threshold and the predetermined coefficient based on the differential signal and/or the orthogonally transformed signal.

2. A noise reducer according to claim 1, wherein the input video signal is serial data, and the signal processing portion further includes:

a serial/parallel conversion means for converting the differential signal into a parallel signal and outputting the parallel signal to the orthogonal transformation means, each of the pixel blocks being output as a unit; and

averaging means for averaging the inversely transformed signal based on the predetermined time period so as to convert the inversely transformed signal into serial data and outputting the serial data of the inversely transformed signal to the attenuation means.

3. A noise reducer according to claim 1, wherein the adaptive control means includes:

means for determining the amount of motion for at least one motion component included in the input video signal in the predetermined time period based on at least one of the differential signal and/or the orthogonally transformed signal; and

parameter control means for controlling at least one of the predetermined threshold and/or the predetermined coefficient based on the amount of motion.

4. A noise reducer according to claim 3, wherein the means for determining the amount of the motion includes absolute value calculation means for receiving the differential signal for each of the pixel blocks composed of m samples in a horizontal direction and n lines in a vertical direction (m, n = natural numbers) and calculating the absolute value of data of the differential signal at each sample point of the pixel block, and average calculation means for calculating the average of the absolute values, and

the parameter control means includes first control means for controlling the predetermined threshold for the nonlinear processing means based on an output from the average calculation means, and second control means for controlling the predetermined coefficient for the attenuation means based on the output from the average calculation means.

5. A noise reducer according to claim 3, wherein the means for determining the amount of the motion includes absolute value calculation means for receiving the orthogonally transformed signal and calculating the absolute value of each component of the orthogonally transformed signal, and dispersion parameter calculation means for calculating a dispersion parameter representing the degree of dispersion of the absolute value, and

the parameter control means includes first control means for controlling the predetermined threshold for the nonlinear processing means based on an output from the dispersion parameter calculation means, and second control means for controlling the predetermined coefficient for the attenuation means based on the output from the dispersion parameter calculation means.

6. A noise reducer according to claim 3, wherein the means for determing the amount of the motion includes absolute value calculation means for receiving the orthogonally transformed signal and calculating the absolute values of the k components (k = natural number) of the orthogonally transformed signal, and

the parameter control means includes first control means for controlling the predetermined threshold for the nonlinear processing means based on at least one of the outputs from the absolute value calculation means, and second control means for controlling the predetermined coefficient for the attenuation means based on at least one of the outputs from the absolute calculation means.

7. A noise reducer according to claim 3, wherein the means for determing the amount of the motion includes isolated-point removal means for receiving the orthogonally transformed signal and removing isolated points from the i components among the k components (i = natural number less than k, k = natural number equal to or greater than 2) of the orthogonally transformed signal, first absolute value calculation means for calculating absolute values of the i components output from the isolated-point removal means, and second absolute value calculation means for calculating absolute values of the (k - i) components on which isolated-point removal is not conducted, and

the parameter control means includes first control means for controlling the predetermined threshold for the nonlinear processing means based on an output from the first absolute value calculation means and/or the second absolute value calculation means, and second control means for controlling the predetermined coefficient for the attenuation means based on the output from the first absolute value calculation means and/or the second absolute value calculation means.

8. A noise reducer according to claim 7, wherein the isolated-point removal means includes filter means for determining whether or not each of the i component of the orthogonally transformed signal is isolated in at least one of three directions corresponding to a horizontal direction, a vertical direction, and a temporal direction of the pixel block, and outputting a modified value for the component when the component is determined as being isolated.

9. A noise reducer according to claim 1, further comprising additional control means for receiving the differential signal, detecting the amplitude of noise included in the differential signal, and outputting the amplitude of the noise to the adaptive control means as an additional control signal for further adjusting at least one of the predetermined threshold and the predetermined coefficient.

10. A noise reducer according to claim 1, further comprising additional control means for receiving the input video signal, extracting a predetermined parameter from the input video signal, and outputting the extracted parameter to the adaptive control means as an additional control signal for further adjusting the predetermined threshold and/or the predetermined coefficient.

11. A noise reducer according to claim 10, wherein the parameter extracted by the additional control means is one of the type, amplitude, and level of the input video signal.

12. A noise reducer for outputting a noise-reduced signal by extracting noise included in an input video signal so as to produce a noise signal and by subtracting the noise signal from the input video signal, the noise reducer comprising:

a signal processing portion including:

first delay means for delaying the noise-reduced signal by a predetermined time period so as to output a first delayed signal;

first subtraction means for subtracting the first delayed signal from the input video signal to output a differential signal;

transformation means for receiving the differential signal and a second delayed signal and conducting an orthogonal transformation on the differential signal and the second delayed signal, each of pixel blocks of the differential signal and the second delayed signal being transformed as a unit, so as to output an orthogonally transformed signal;

nonlinear processing means for receiving the orthogonally transformed signal and conducting nonlinear processing on the orthogonally transformed signal based on a predetermined threshold so as to output a nonlinear processed signal;

inverse transformation means for receiving the nonlinear processed signal and conducting inverse transformation of the orthogonal transformation on the nonlinear processed signal so as to output an inversely transformed signal;

attenuation means for receiving the inversely transformed signal and attenuating the inversely transformed signal by a predetermined coefficient to output the noise signal; and

second delay means for delaying the inversely transformed signal by another predetermined time period to output the second delayed signal;

second subtraction means for subtracting the noise signal from the input video signal to output the noise-reduced signal; and

adaptive control means for controlling at least one of the predetermined threshold and the predetermined coefficient based on the differential signal and/or the orthogonally transformed signal.

13. A noise reducer according to claim 12, wherein the input video signal and the second delayed signal are serial data, and the signal processing portion further includes:

a serial/parallel conversion means for converting the differential signal and the second delayed signal into a parallel signal and outputting the parallel signal to the orthogonal transformation means, each of the pixel blocks being output as a unit; and

averaging means for averaging the inversely transformed signal based on the predetermined time period so as to convert the inversely transformed signal into serial data and outputting the serial data of the inversely transformed signal to the attenuation means and the second delay means.

14. A noise reducer according to claim 12, wherein the adaptive control means includes:

means for determining the amount of motion for at least one motion component included in the input video signal in the predetermined time period based on at least one of the combination of the differential signal and the second delayed signal and the orthogonally transformed signal; and

parameter control means for controlling of the predetermined threshold and/or the predetermined coefficient based on the amount of motion.

15. A noise reducer according to claim 14, wherein the means for determining the amount of the motion includes absolute value calculation means for receiving the differential signal and the second delayed signal for each of the pixel blocks composed of m samples in a horizontal direction and n lines in a vertical direction (m, n = natural numbers) and calculating the absolute value of data of the differential signal at each sample point of the pixel block, and average calculation means for calculating the average of the absolute values, and

the parameter control means includes first control means for controlling the predetermined threshold for the nonlinear processing means based on an output from the average calculation means, and second control means for controlling the predetermined coefficient for the attenuation means based on the output from the average calculation means.

16. A noise reducer according to claim 14, wherein the motion amount determination means includes absolute value calculation means for receiving the orthogonally transformed signal and calculating the absolute value of each component of the orthogonally transformed signal, and dispersion parameter calculation means for calculating a dispersion parameter representing the degree of dispersion of the absolute value, and

the parameter control means includes first control means for controlling the predetermined threshold for the nonlinear processing means based on an output from the dispersion parameter calculation means, and second control means for controlling the predetermined coefficient for the attenuation means based on the output from the dispersion parameter calculation means.

17. A noise reducer according to claim 14, wherein the means for determining the amount of the motion includes absolute value calculation means for receiving the orthogonally transformed signal and calculating the absolute values of k components (k = natural number) of the orthogonally transformed signal, and

the parameter control means includes first control means for controlling the predetermined threshold for the nonlinear processing means based on at least one of outputs from the k absolute value calculation means, and second control means for controlling the predetermined coefficient for the attenuation means based on at least one of the outputs from the k absolute calculation means.

18. A noise reducer according to claim 14, wherein the means for determining the amount of the motion includes isolated-point removal means for receiving the orthogonally transformed signal and removing isolated points from the i components among the k components (i = natural number less than k, k = natural number equal to or greater than 2) of the orthogonally transformed signal, first absolute value calculation means for calculating absolute values of the i components output from the isolated-point removal means, and second absolute value calculation means for calculating absolute values of the (k - i) components on which isolated-point removal is not conducted, and

the parameter control means includes first control means for controlling the predetermined threshold for the nonlinear processing means based on an output from the first absolute value calculation means and/or the second absolute value calculation means, and second control means for controlling the predetermined coefficient for the attenuation means based on the output from the first absolute value calculation means and/or the second absolute value calculation means.

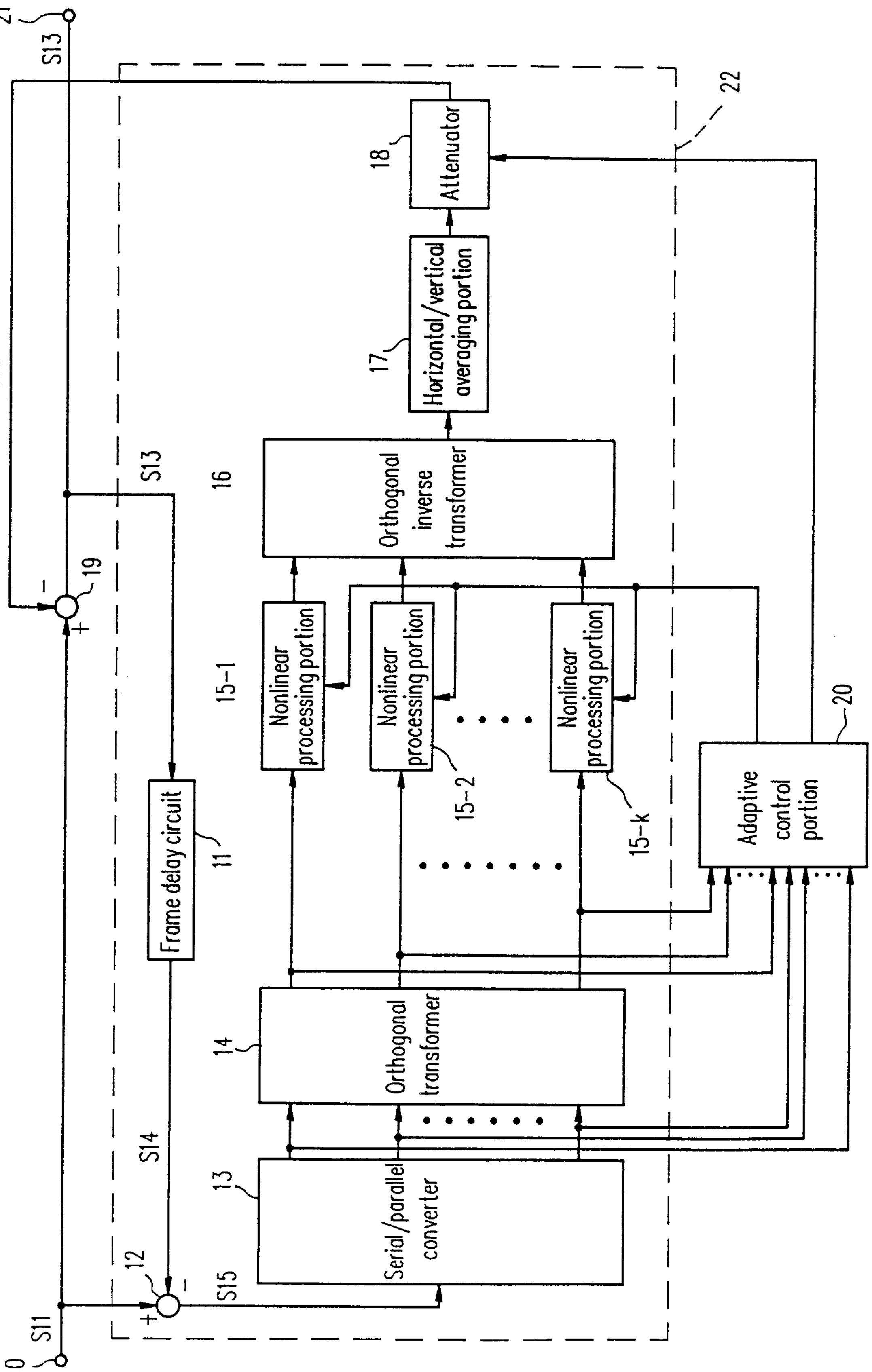
19. A noise reducer according to claim 18, wherein the isolated-point removal means includes filter means for determining whether or not each of the i components of the orthogonally transformed signal is isolated in at least one of three directions corresponding to a horizontal direction, a vertical direction, and a temporal direction of the pixel block, and outputting a modified value for the component when the component is determined as being isolated.

20. A noise reducer according to claim 12, further comprising additional control means for receiving the differential signal, detecting the amplitude of noise included in the differential signal, and outputting the amplitude of the noise to the adaptive control means as an additional control signal for further adjusting at least one of the predetermined threshold and the predetermined coefficient.

21. A noise reducer according to claim 12, further comprising additional control means for receiving the input video signal, extracting a predetermined parameter from the input video signal, and outputting the extracted parameter to the adaptive control means as an additional control signal for further adjusting the predetermined threshold and/or the predetermined coefficient.

22. A noise reducer according to claim 21, wherein the parameter extracted by the additional control means is one of the type, amplitude, and level of the input video signal.

FIG.1


100
10
S11
21
S13
S12
S14
S15
12
19
22
Frame delay circuit
11
Serial/parallel converter
13
Orthogonal transformer
14
Nonlinear processing portion
15-1
15-2
15-k
Orthogonal inverse transformer
16
Horizontal/vertical averaging portion
17
Attenuator
18
Adaptive control portion
20

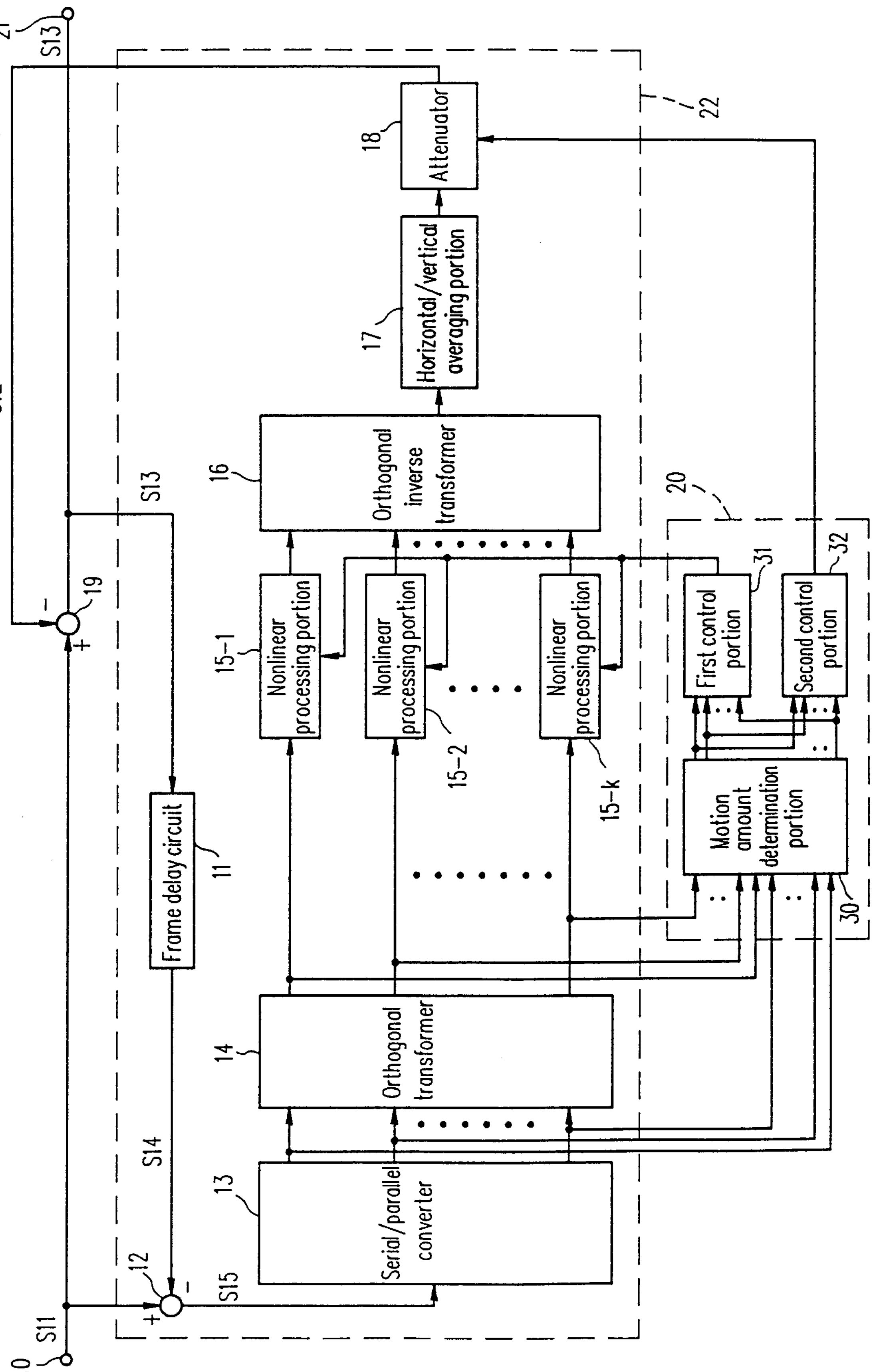

200
21
S13
S12
Attenuator
18
22
Horizontal/vertical averaging portion
17
Orthogonal inverse transformer
16
S13
19
20
Nonlinear processing portion
15-1
15-2
15-k
First control portion
31
Second control portion
32
Frame delay circuit
11
Motion amount determination portion
30
Orthogonal transformer
14
S14
Serial/parallel converter
13
12
S15
10
S11

FIG. 2

FIG.3

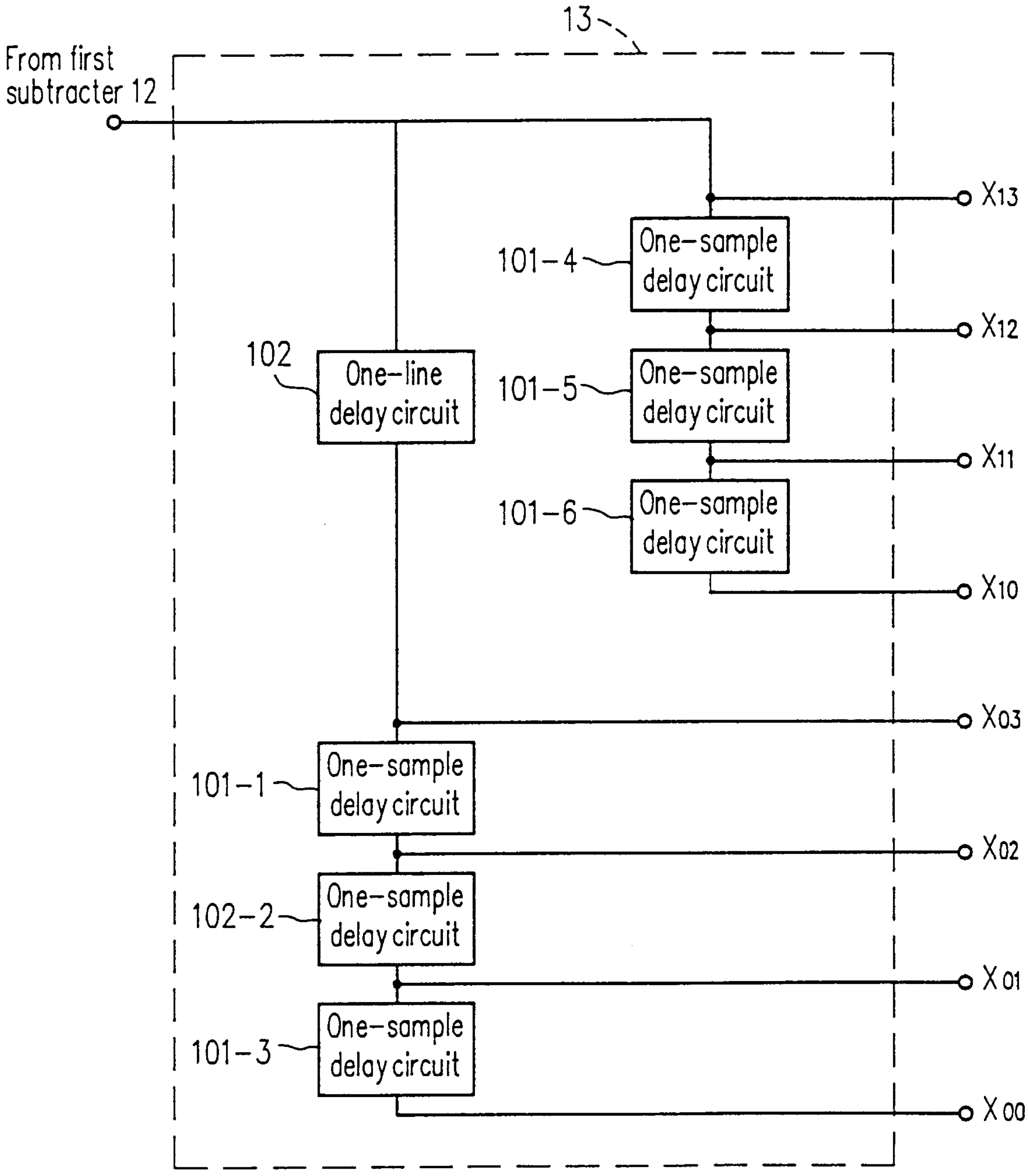

13
From first
subtracter 12
One-line
delay circuit
102
One-sample
delay circuit
101-4
101-5
101-6
101-1
102-2
101-3
X13
X12
X11
X10
X03
X02
X01
X00

FIG. 4

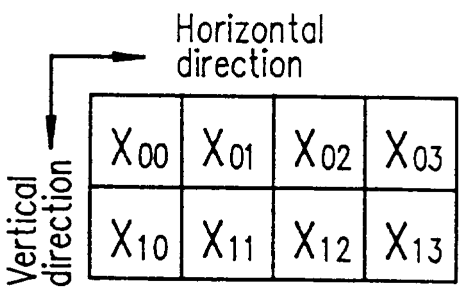
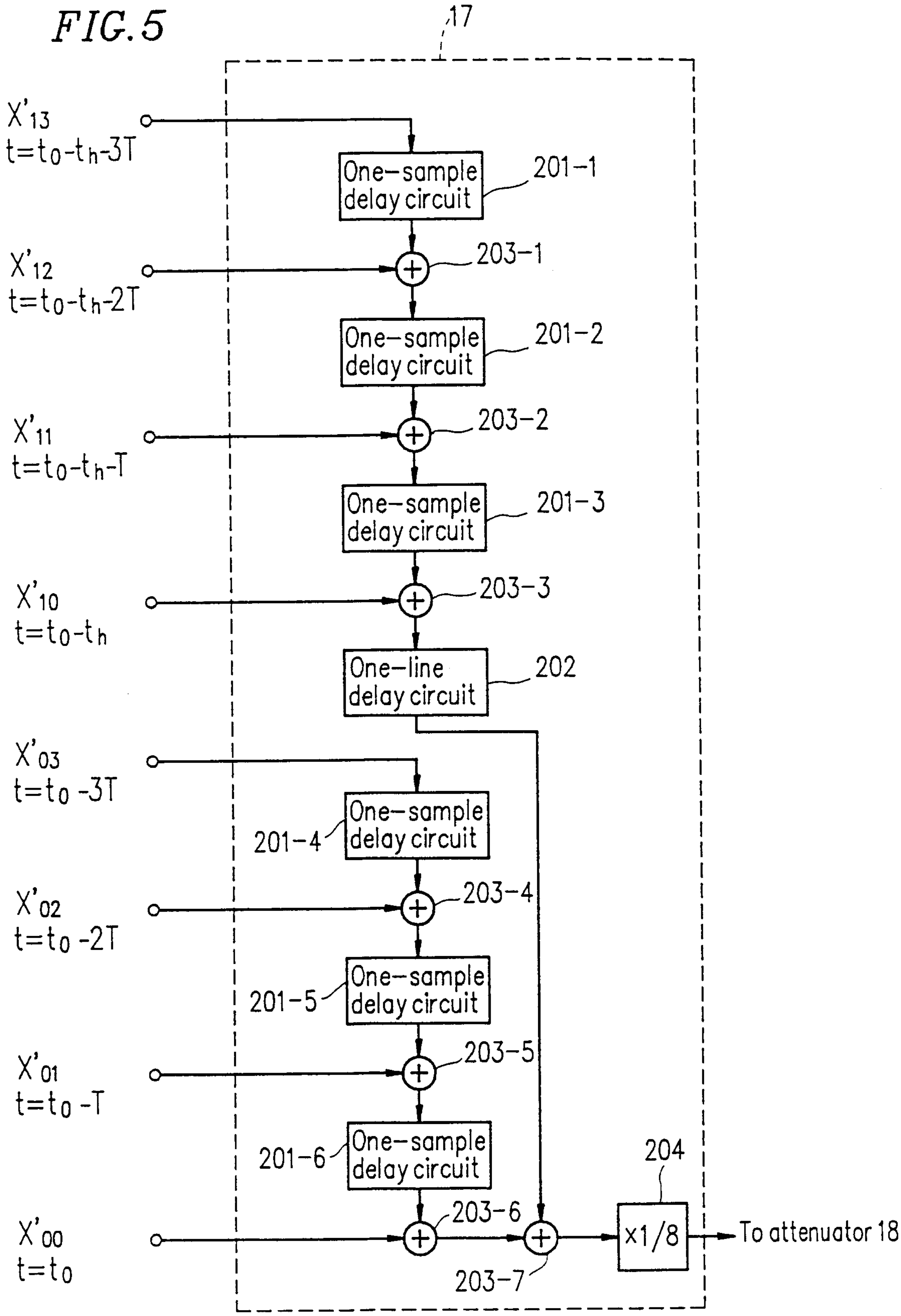

Horizontal direction
Vertical direction
X00
X01
X02
X03
X10
X11
X12
X13

FIG. 5



T : 1 sample period
t_h : 1 line period

FIG.6A

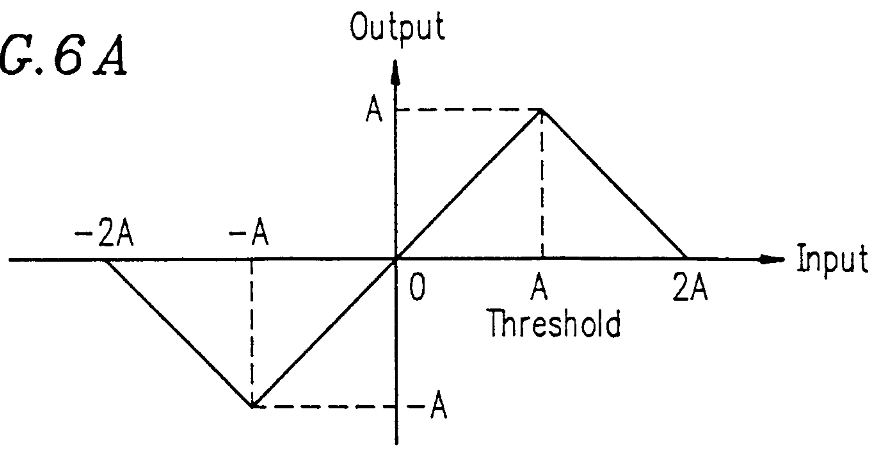


FIG.6B

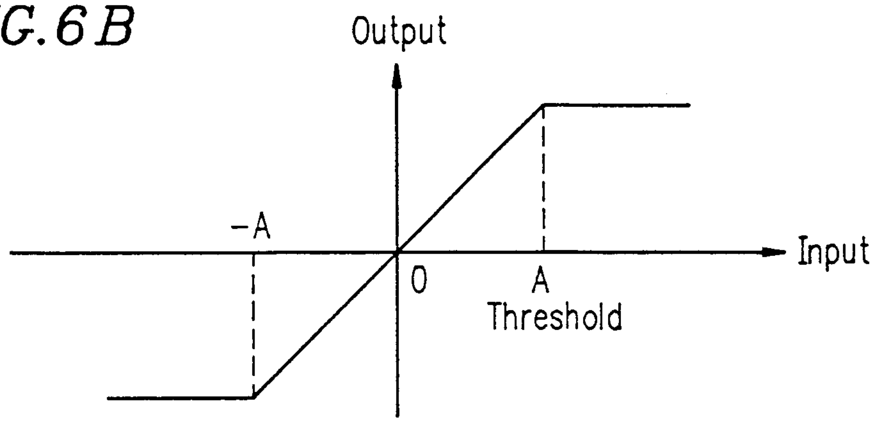


FIG.6C

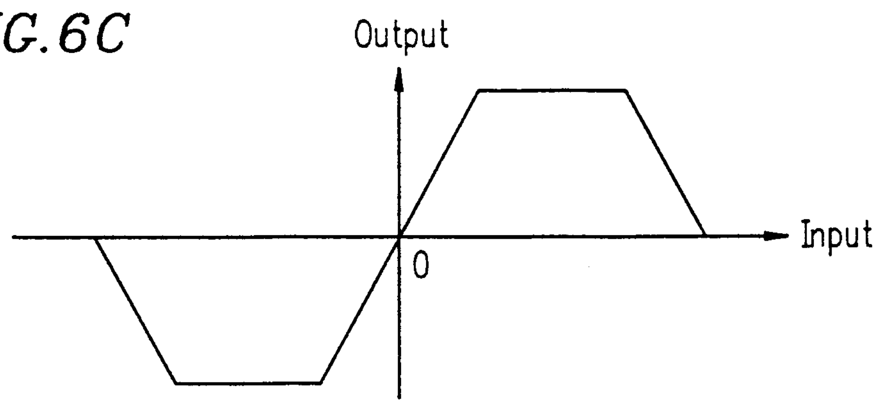


FIG.6D

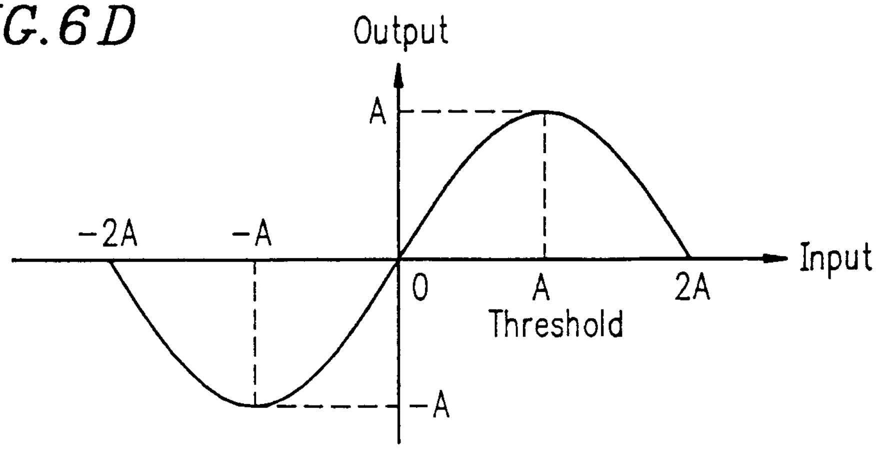


FIG. 7

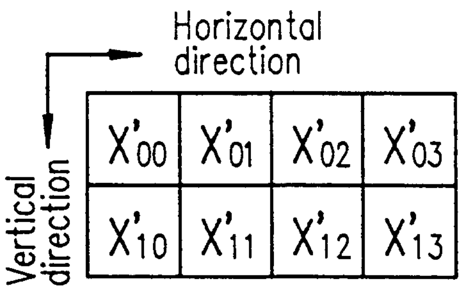
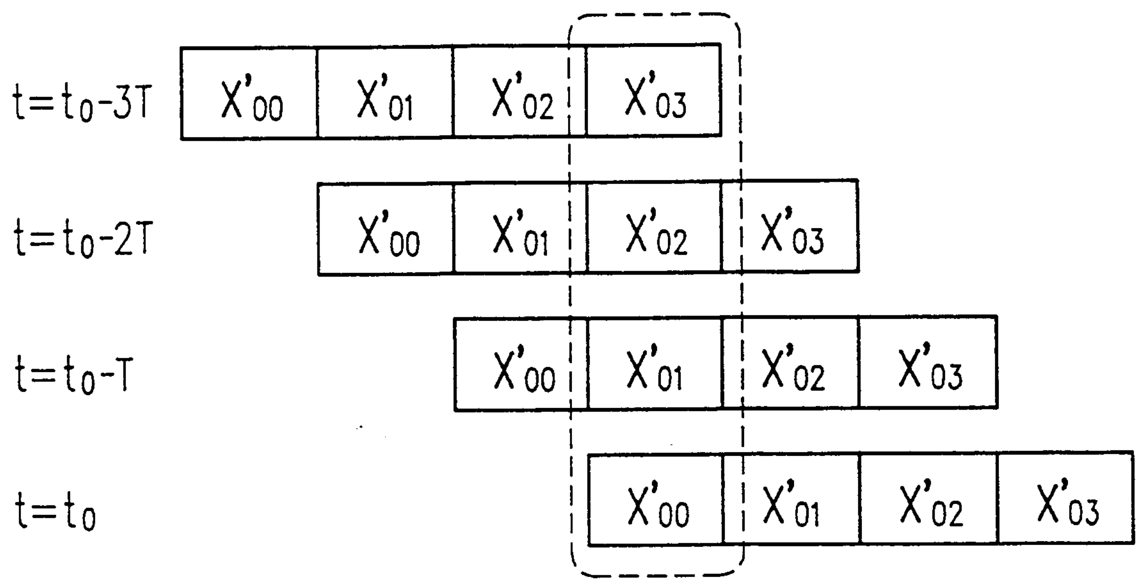

Horizontal direction
Vertical direction
X'00
X'01
X'02
X'03
X'10
X'11
X'12
X'13

FIG. 8



T: Sample period

FIG.9

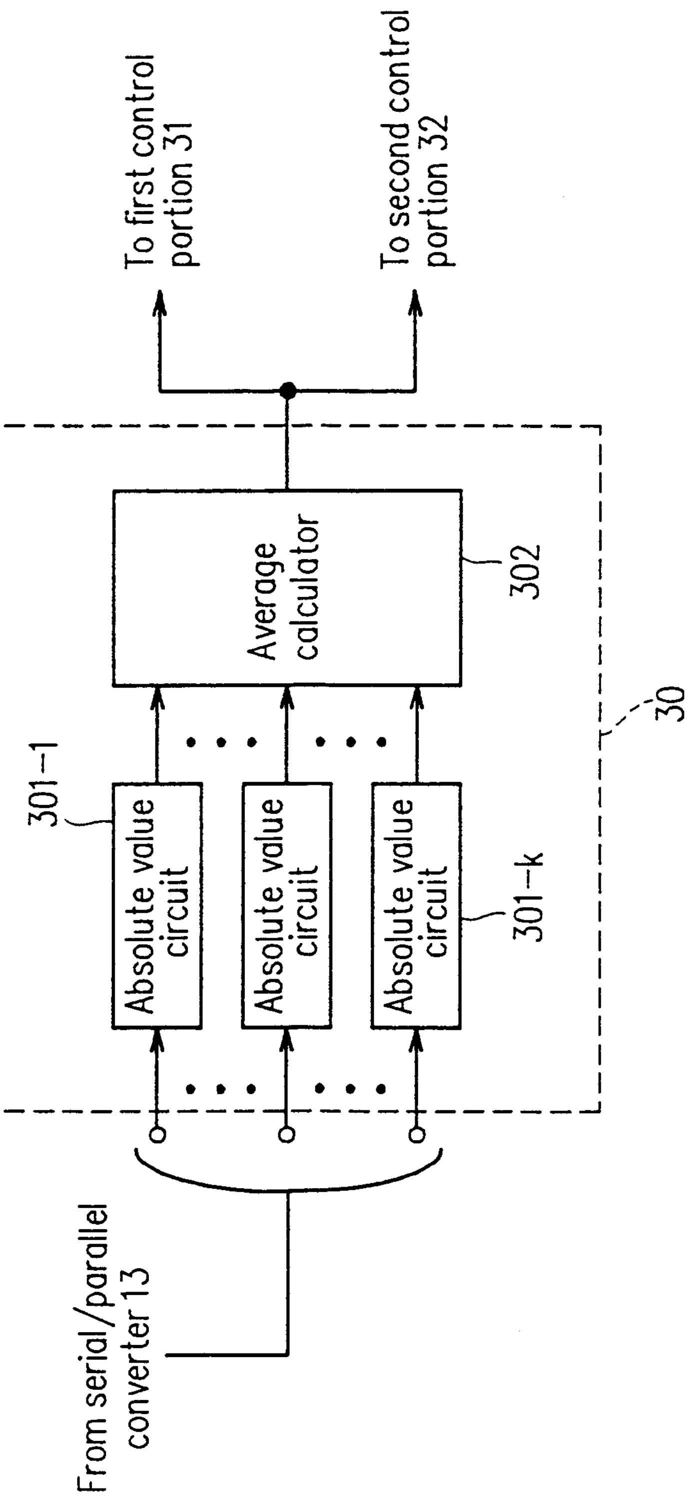

To first control portion 31
To second control portion 32
Average calculator
302
Absolute value circuit
Absolute value circuit
Absolute value circuit
301-1
301-k
30
From serial/parallel converter 13

FIG.10

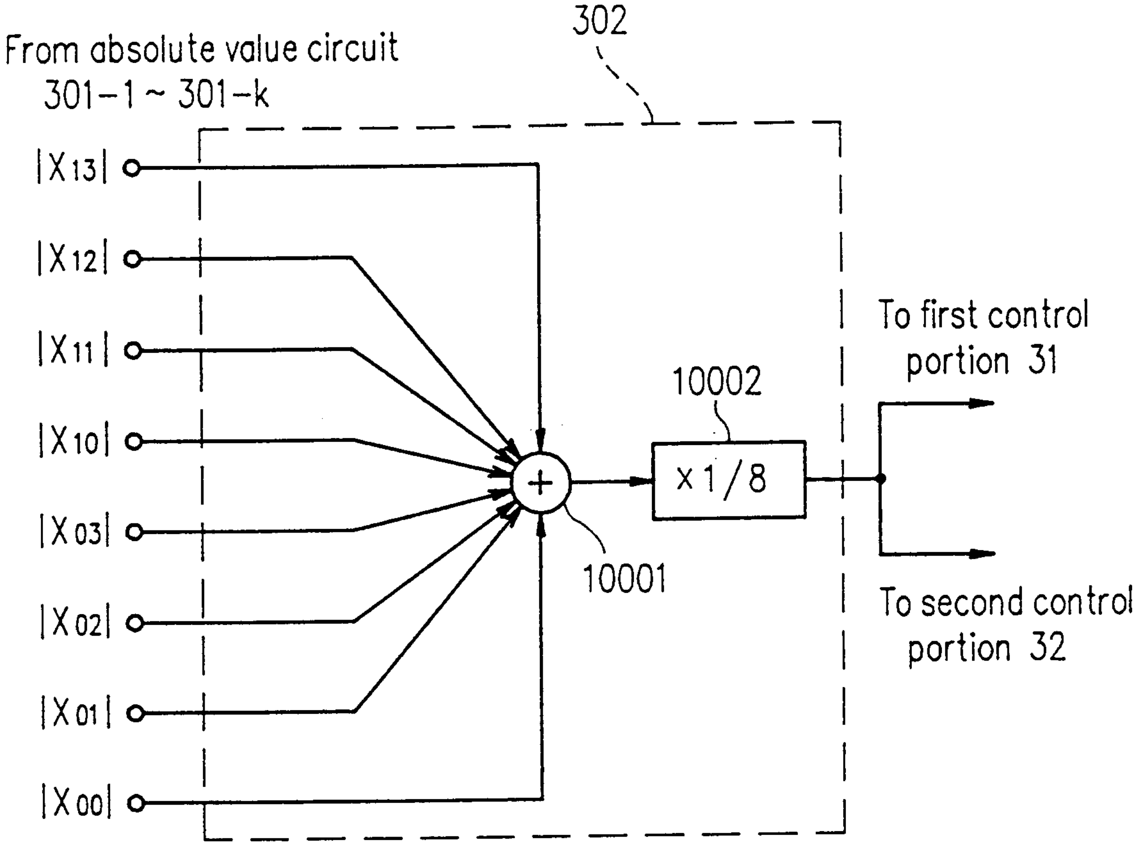

302
From absolute value circuit
301-1 ~ 301-k
|X13|
|X12|
|X11|
|X10|
|X03|
|X02|
|X01|
|X00|
+
10001
10002
x1/8
To first control portion 31
To second control portion 32

FIG.11

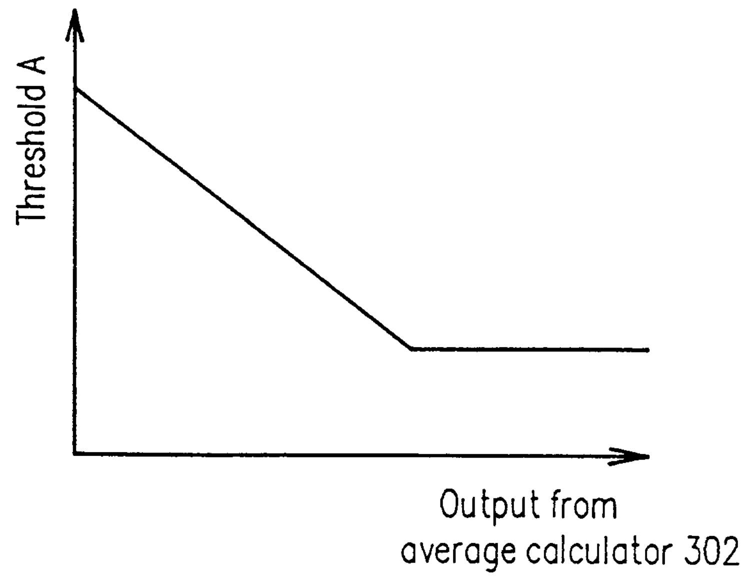

Threshold A
Output from
average calculator 302

FIG.12

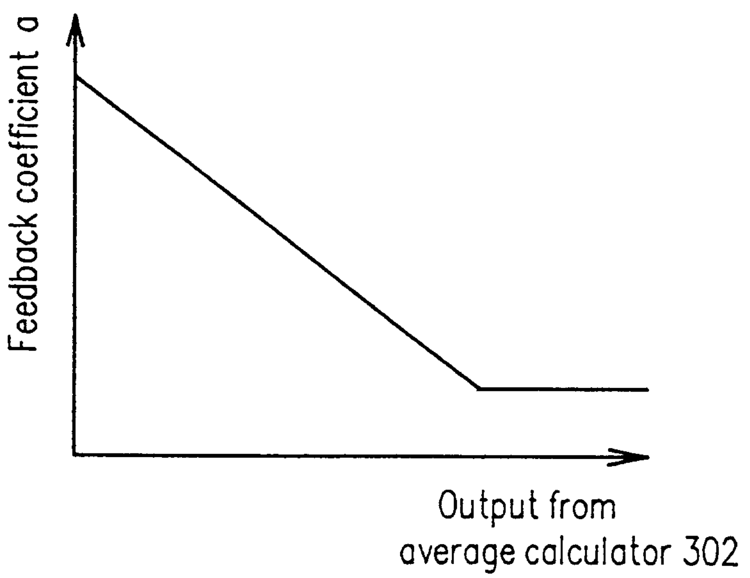

Feedback coefficient a
Output from
average calculator 302

FIG.13

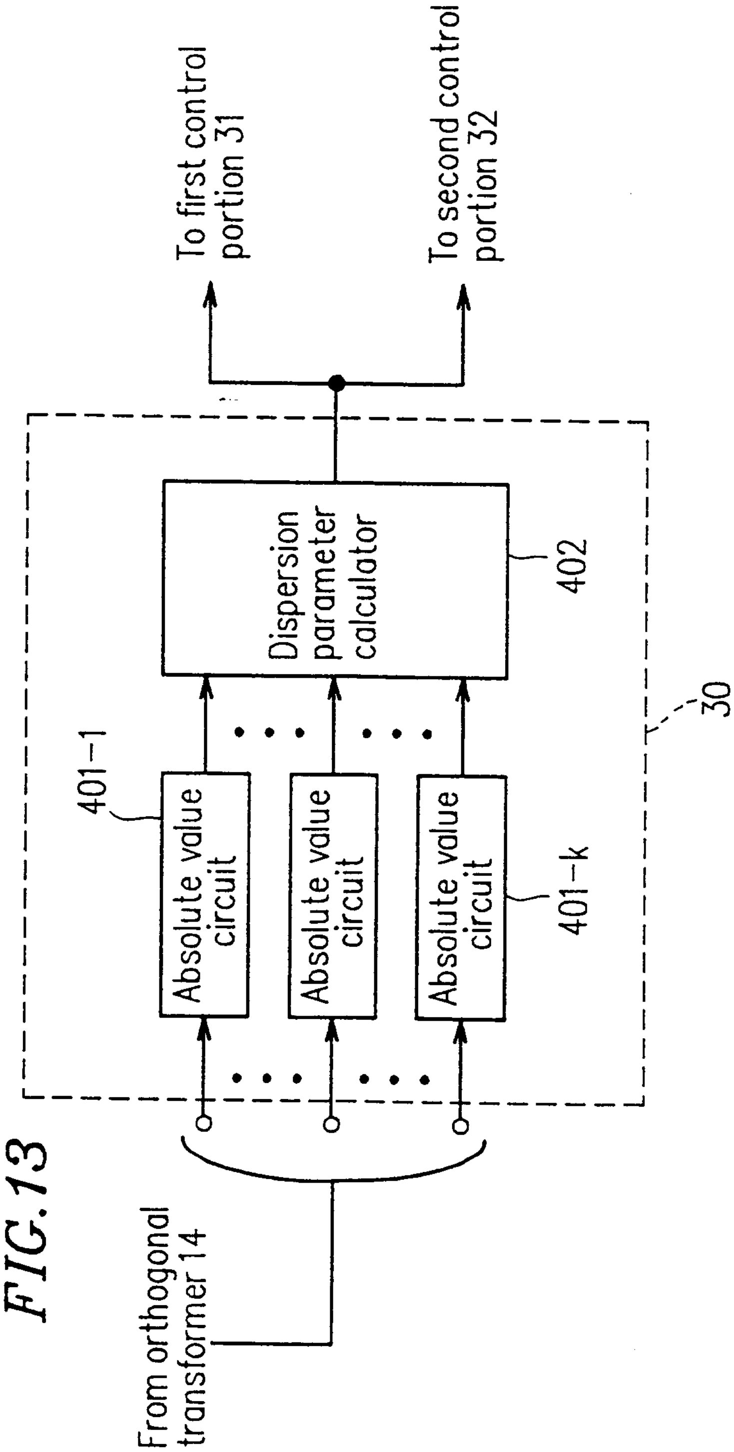

To first control portion 31
To second control portion 32
Dispersion parameter calculator
402
Absolute value circuit
Absolute value circuit
Absolute value circuit
401-1
401-k
30
From orthogonal transformer 14

FIG.14

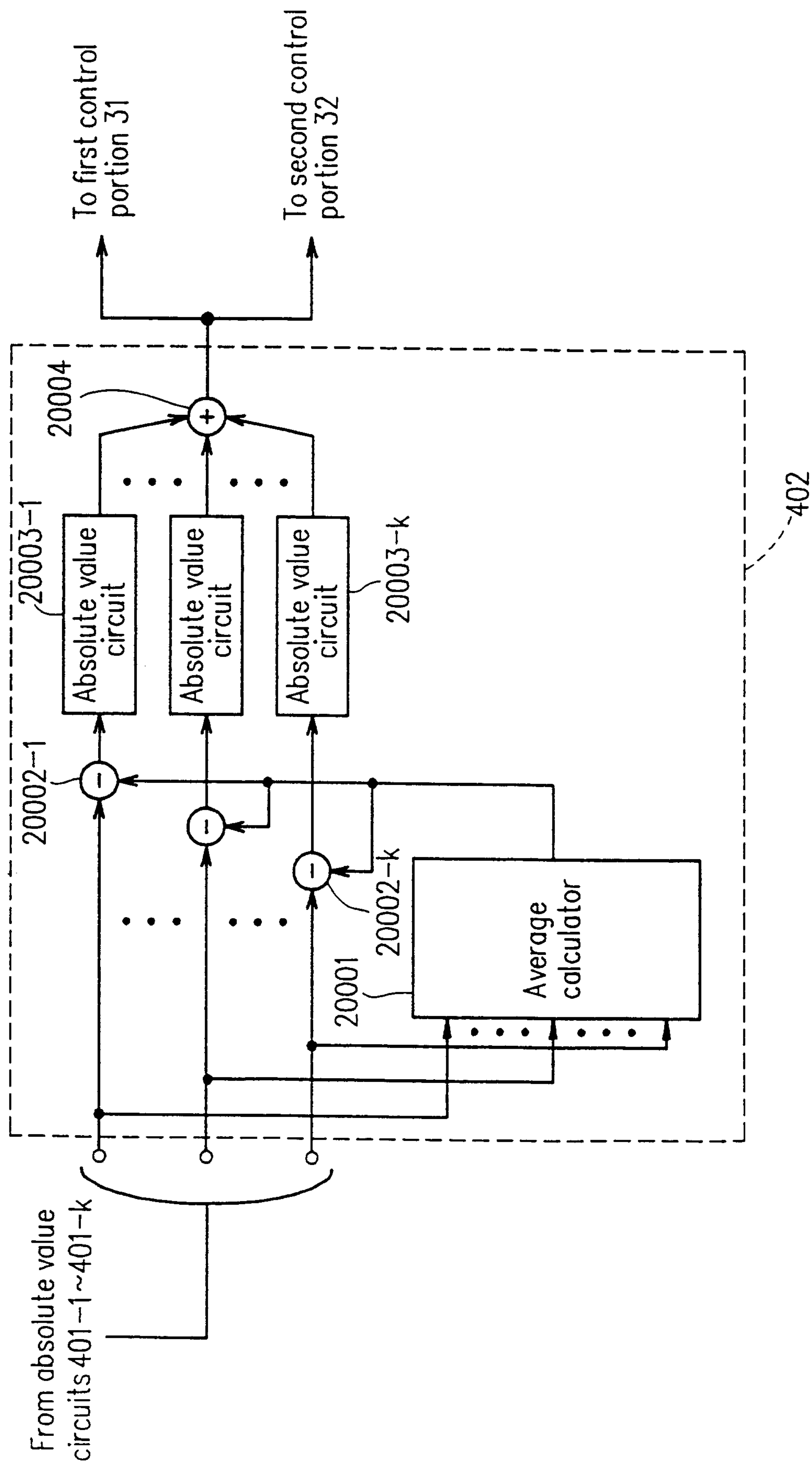

To first control portion 31
To second control portion 32
20004
20003-1
Absolute value circuit
Absolute value circuit
Absolute value circuit
20003-k
402
20002-1
20002-k
20001
Average calculator
From absolute value circuits 401-1~401-k

FIG.15

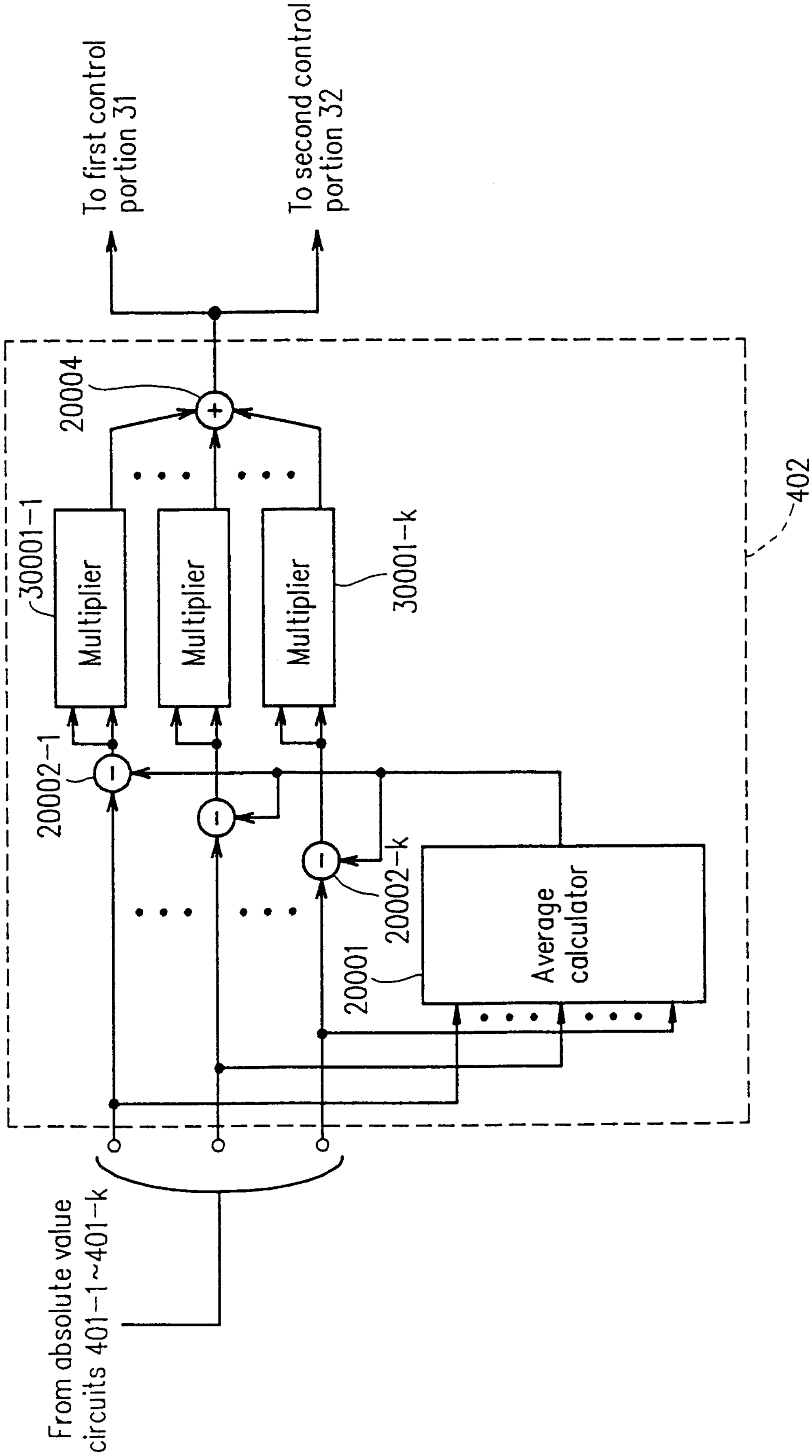

To first control portion 31
To second control portion 32
20004
30001-1
Multiplier
Multiplier
Multiplier
30001-k
402
20002-1
20002-k
Average calculator
20001
From absolute value circuits 401-1~401-k

FIG.16A

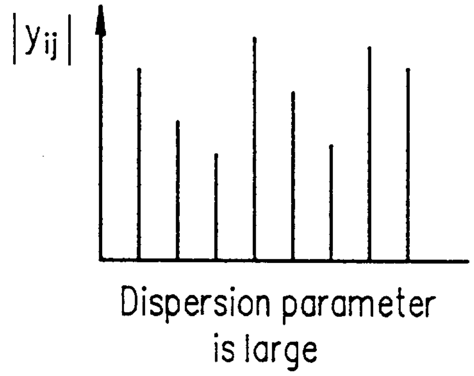


FIG.16B

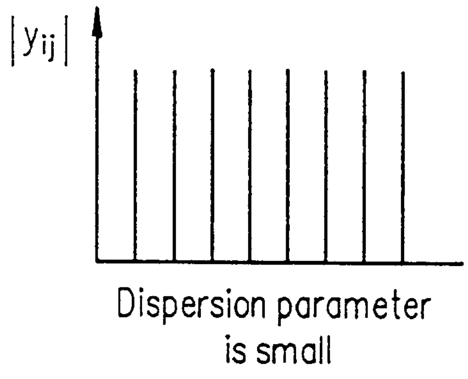


FIG.17

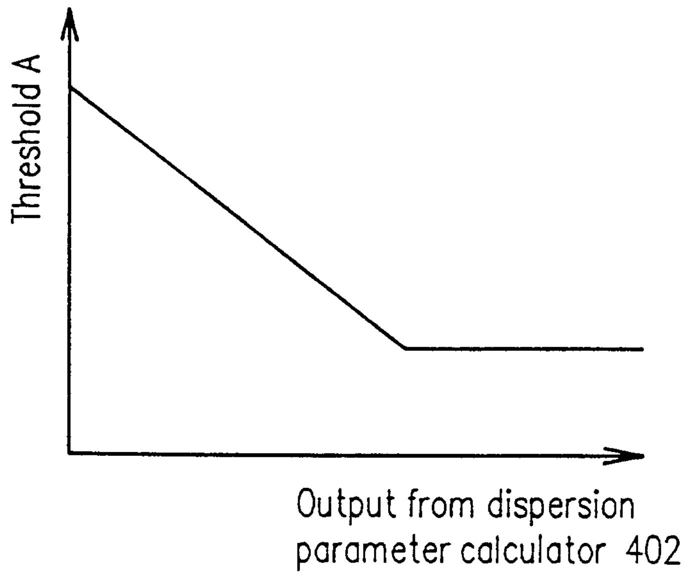

Threshold A
Output from dispersion
parameter calculator 402

FIG.18

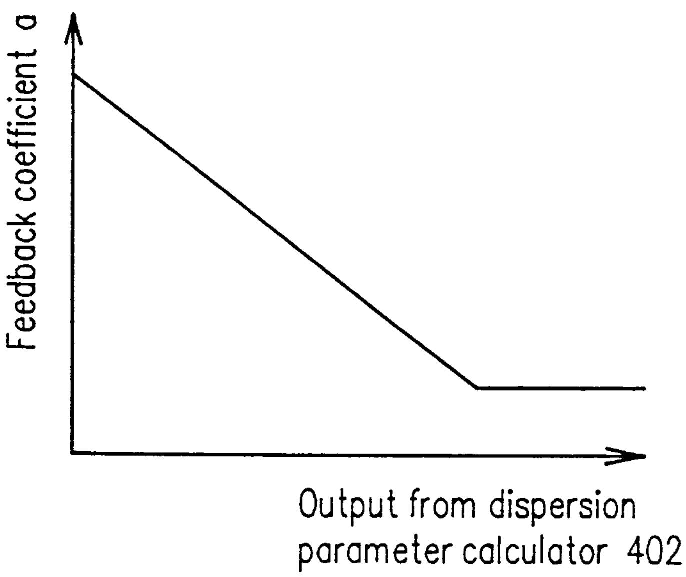

Feedback coefficient a
Output from dispersion
parameter calculator 402

FIG.19

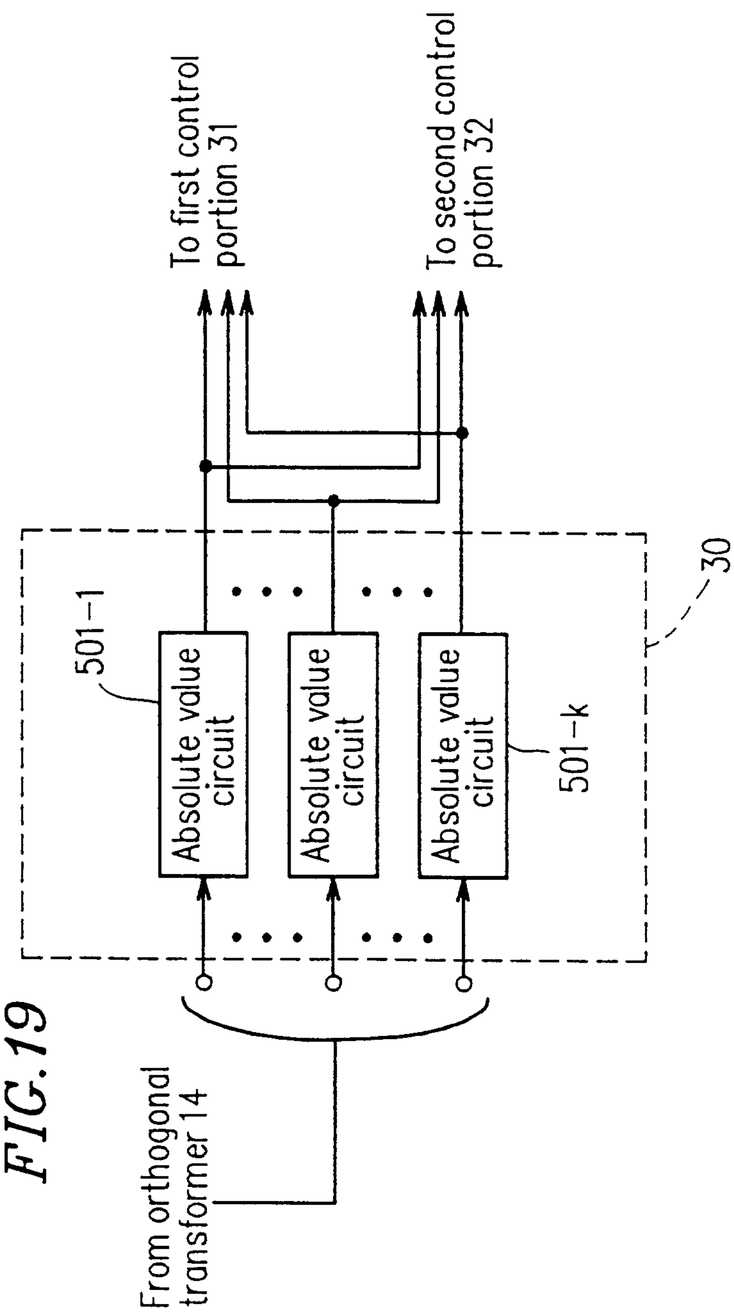

To first control portion 31
To second control portion 32
501-1
Absolute value circuit
Absolute value circuit
Absolute value circuit
501-k
30
From orthogonal transformer 14

FIG. 20

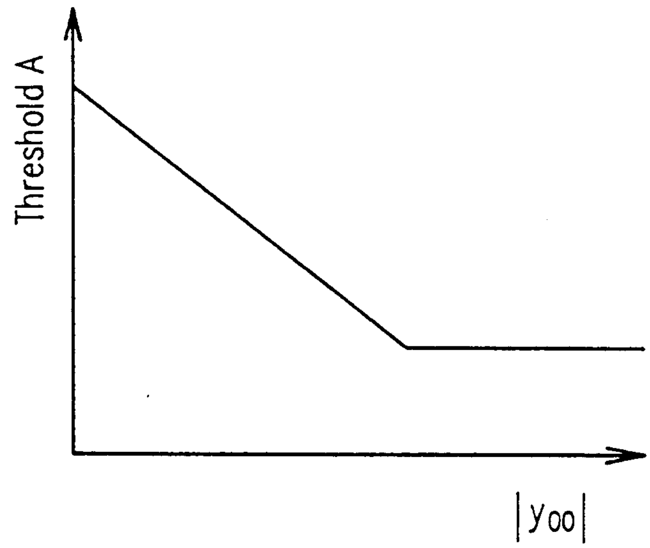
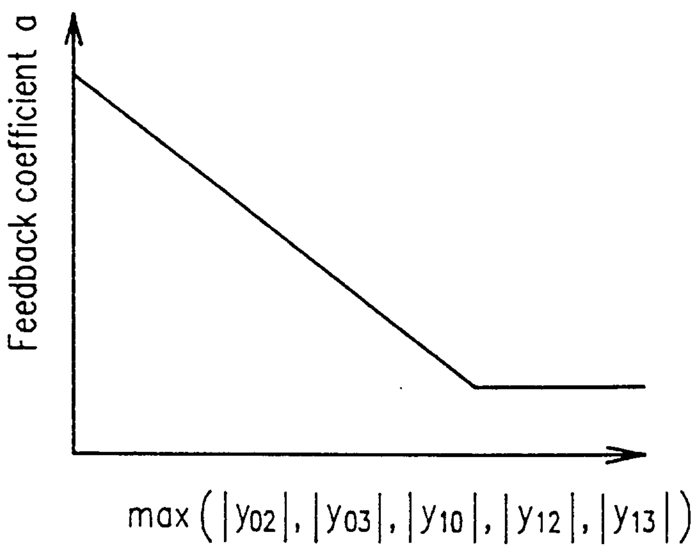

Threshold A
|y00|

FIG. 21


Feedback coefficient a
max(|y02|, |y03|, |y10|, |y12|, |y13|)

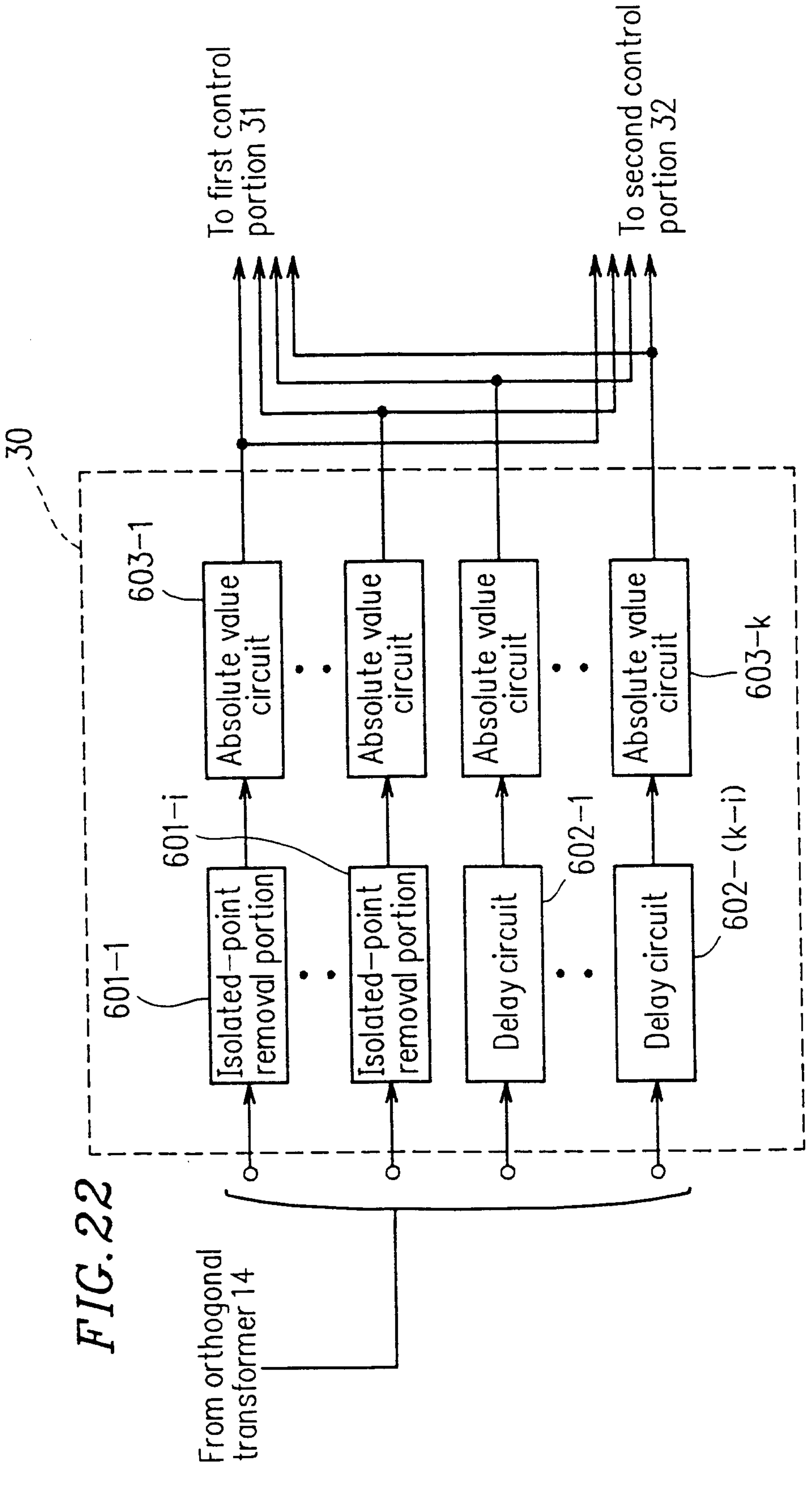

To first control portion 31
To second control portion 32
30
603-1
Absolute value circuit
Absolute value circuit
Absolute value circuit
Absolute value circuit
603-k
601-1
601-i
Isolated-point removal portion
Isolated-point removal portion
Delay circuit
602-1
Delay circuit
602-(k-i)
From orthogonal transformer 14

FIG. 22

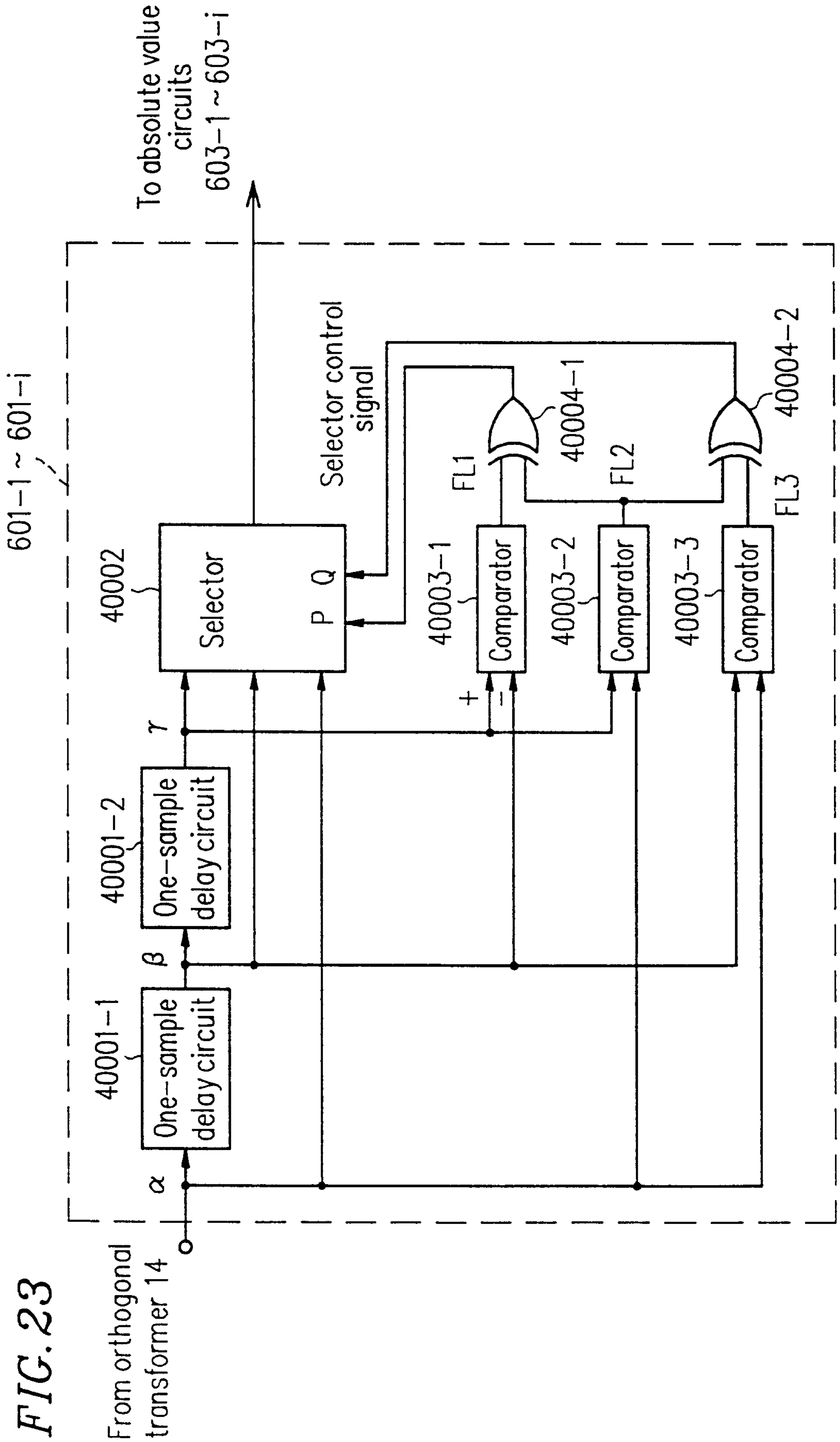
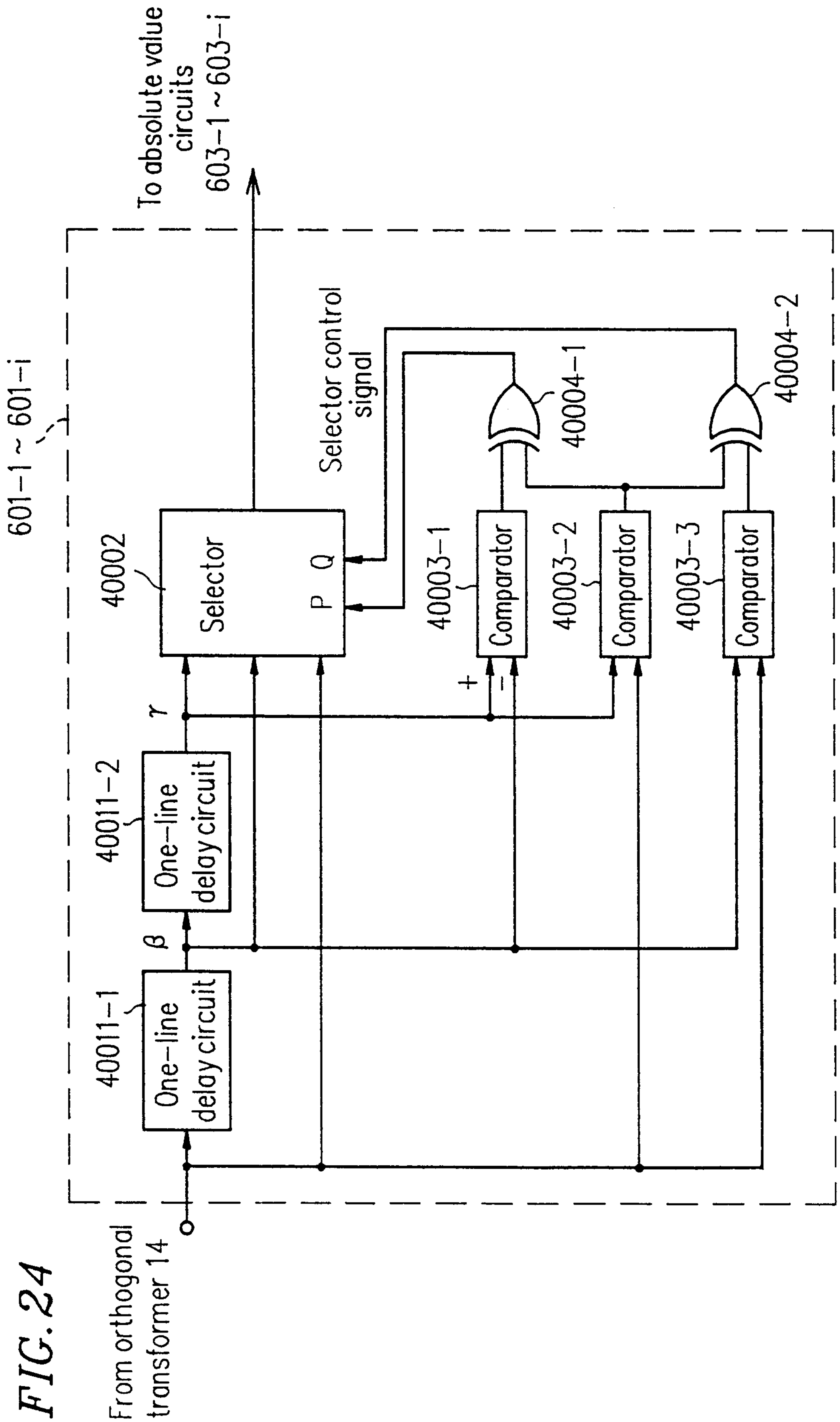

From orthogonal transformer 14
α
β
γ
40001-1
One-sample delay circuit
40001-2
One-sample delay circuit
40002
Selector
P
Q
40003-1
Comparator
+
-
40003-2
Comparator
40003-3
Comparator
FL1
FL2
FL3
40004-1
40004-2
Selector control signal
601-1 ~ 601-i
To absolute value circuits 603-1 ~ 603-i

FIG.23

FIG. 24



To absolute value circuits 603-1 ~ 603-i
601-1 ~ 601-i
Selector control signal
40002
Selector
P
Q
40004-1
40004-2
40003-1
Comparator
40003-2
Comparator
40003-3
Comparator
+
−
γ
β
40011-2
One-line delay circuit
40011-1
One-line delay circuit
From orthogonal transformer 14

FIG. 25

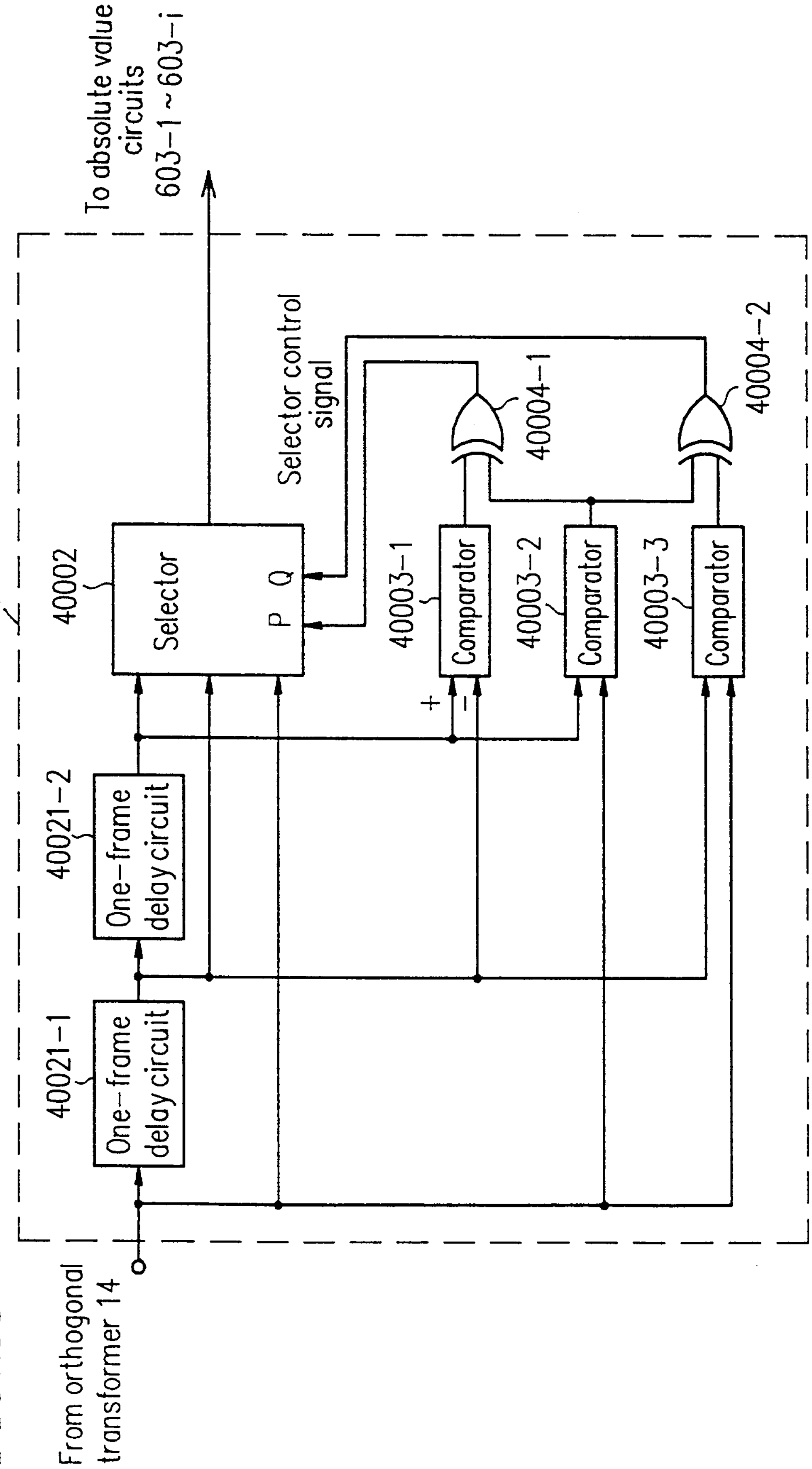

From orthogonal transformer 14
601-1 ~ 601-i
40021-1
One-frame delay circuit
40021-2
One-frame delay circuit
40002
Selector
P
Q
40003-1
Comparator
40003-2
Comparator
40003-3
Comparator
+
-
40004-1
40004-2
Selector control signal
To absolute value circuits 603-1 ~ 603-i

FIG. 26

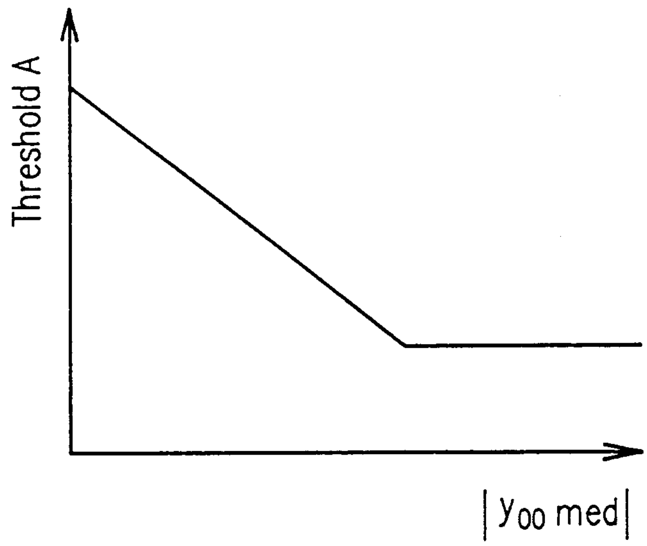

Threshold A
| y00 med |

FIG. 27

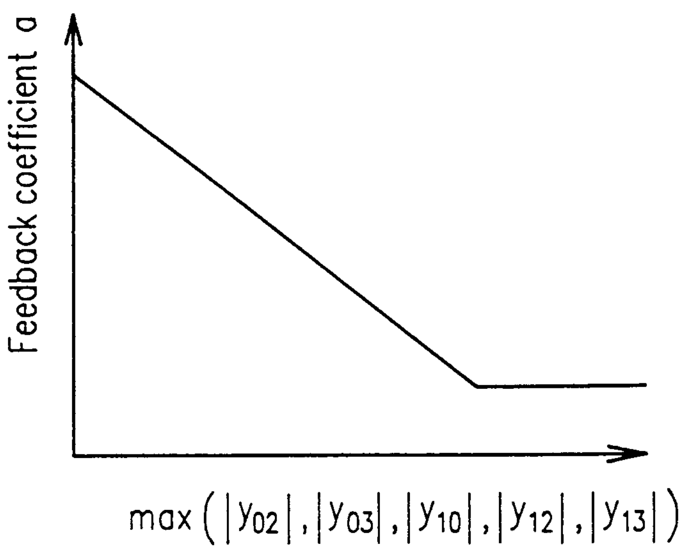

Feedback coefficient a
max (| y02 | , | y03 | , | y10 | , | y12 | , | y13 |)

FIG. 28

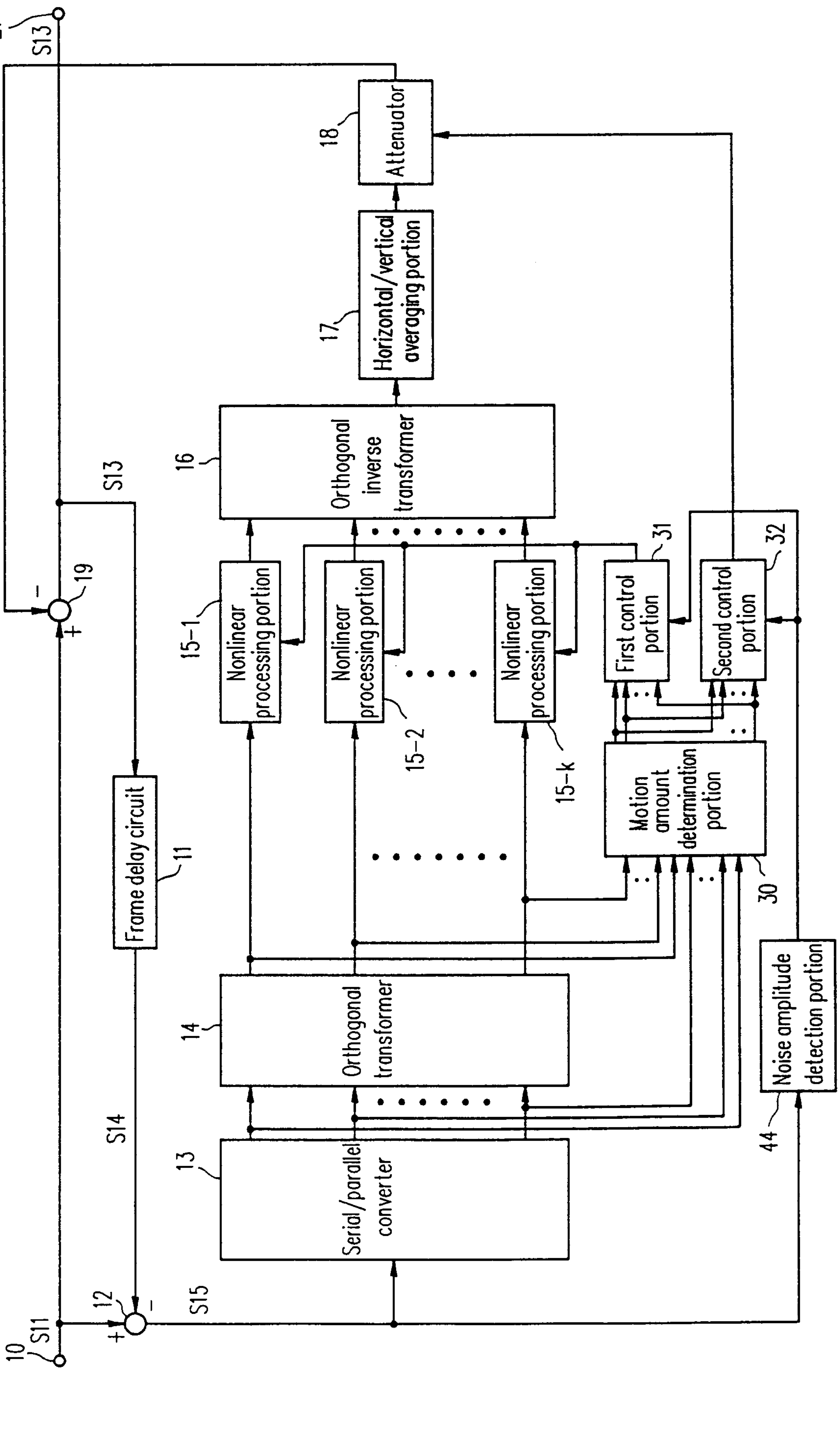

300
10
S11
12
S15
S14
Frame delay circuit
11
Serial/parallel converter
13
Orthogonal transformer
14
Nonlinear processing portion
15-1
15-2
15-k
Orthogonal inverse transformer
16
Horizontal/vertical averaging portion
17
Attenuator
18
S12
S13
19
21
Motion amount determination portion
30
First control portion
31
Second control portion
32
Noise amplitude detection portion
44

FIG. 29

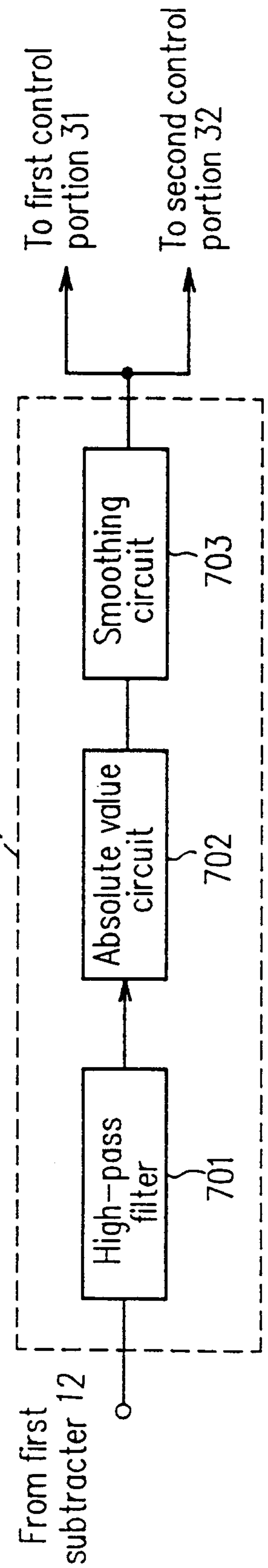

From first
subtracter 12
44
High-pass
filter
701
Absolute value
circuit
702
Smoothing
circuit
703
To first control
portion 31
To second control
portion 32

FIG. 30A

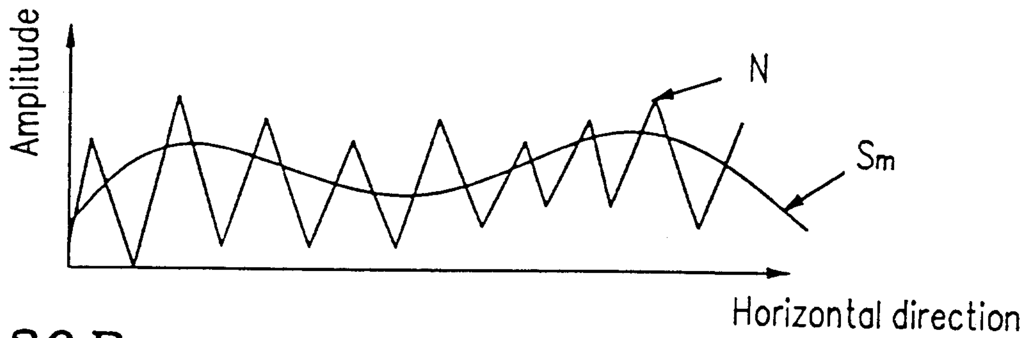


FIG. 30B

FIG. 30C

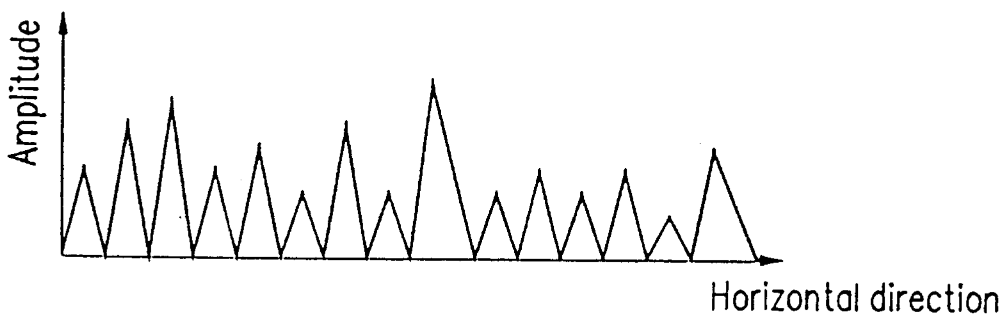


FIG. 30D

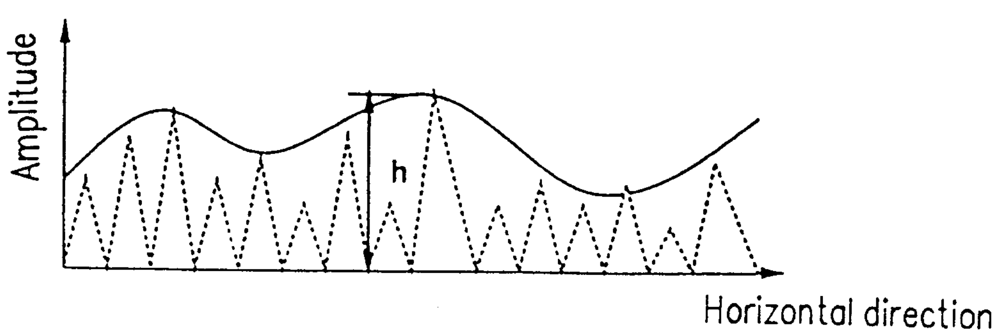


FIG. 31

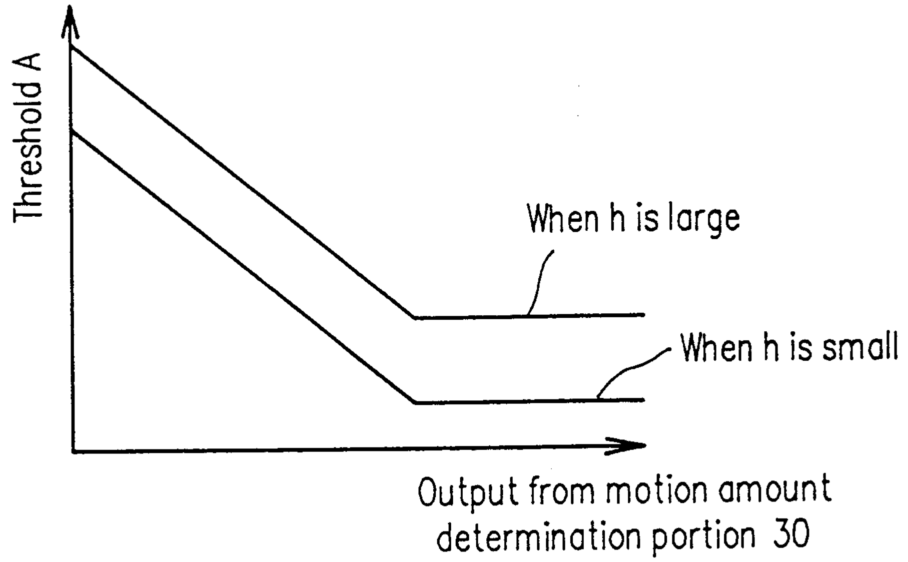

Threshold A
When h is large
When h is small
Output from motion amount determination portion 30

FIG. 32

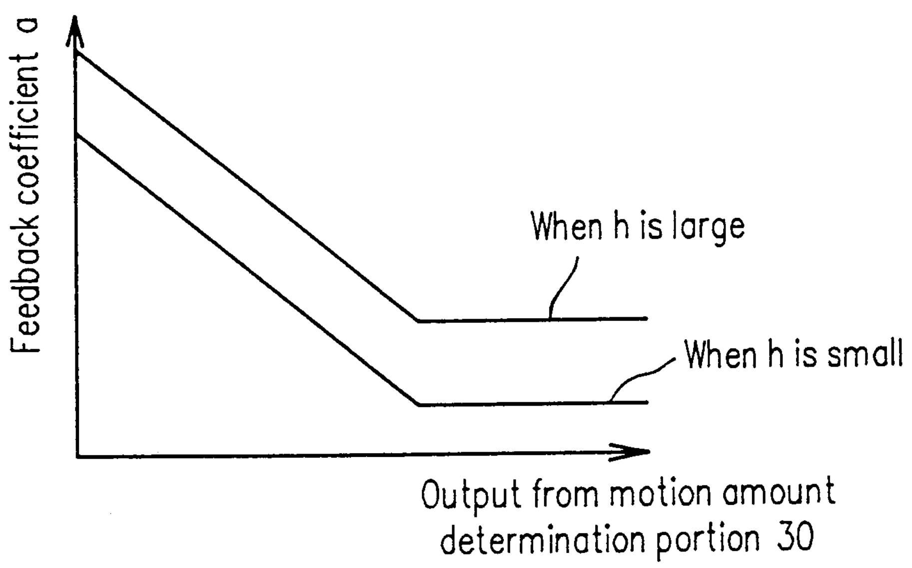
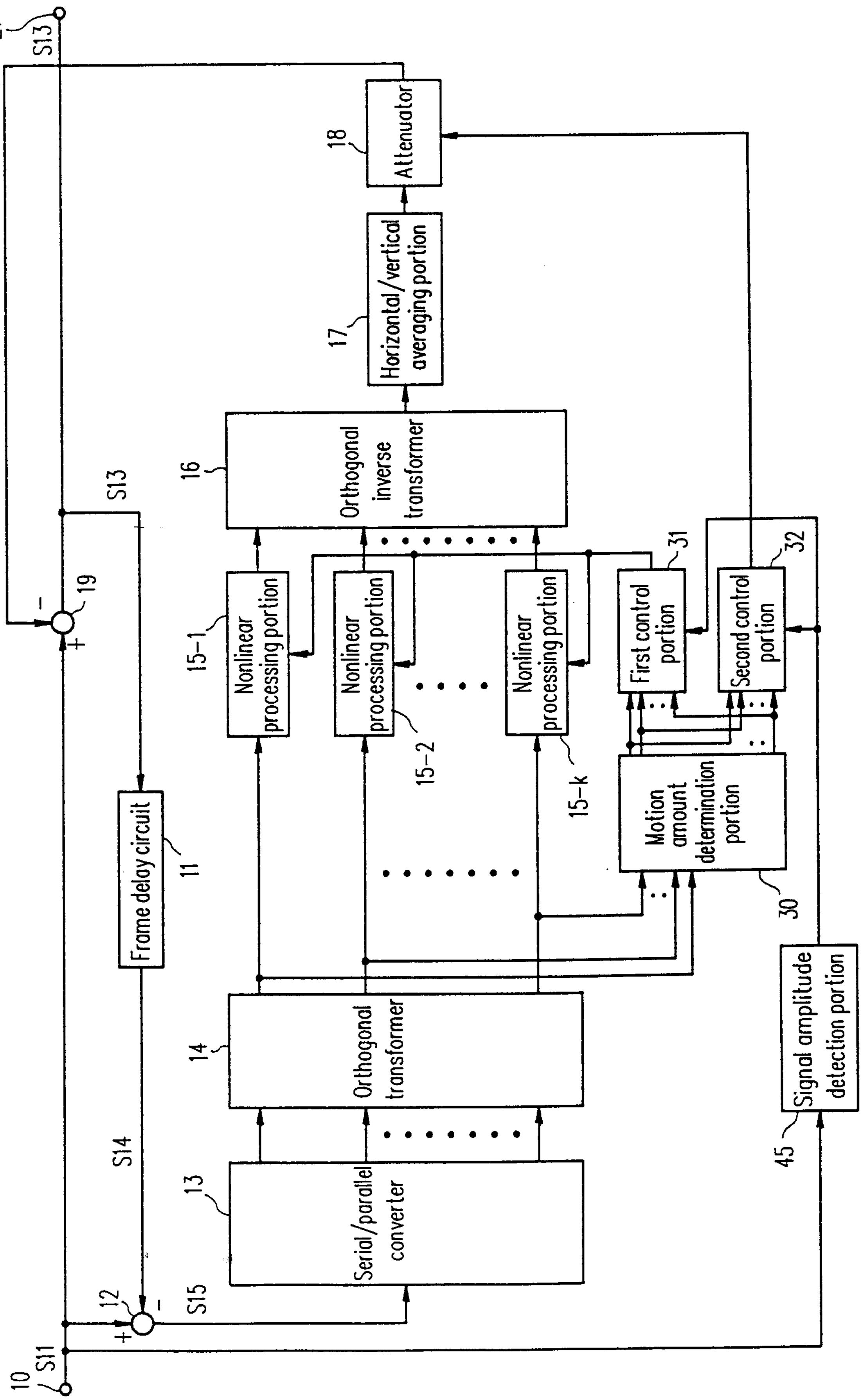

Feedback coefficient a
When h is large
When h is small
Output from motion amount determination portion 30

FIG. 33


400
21
S13
S12
S13
19
+
-
Frame delay circuit
11
S14
12
+
-
S15
10
S11
Serial/parallel converter
13
Orthogonal transformer
14
Nonlinear processing portion
15-1
Nonlinear processing portion
15-2
Nonlinear processing portion
15-k
Orthogonal inverse transformer
16
Horizontal/vertical averaging portion
17
Attenuator
18
First control portion
31
Second control portion
32
Motion amount determination portion
30
Signal amplitude detection portion
45

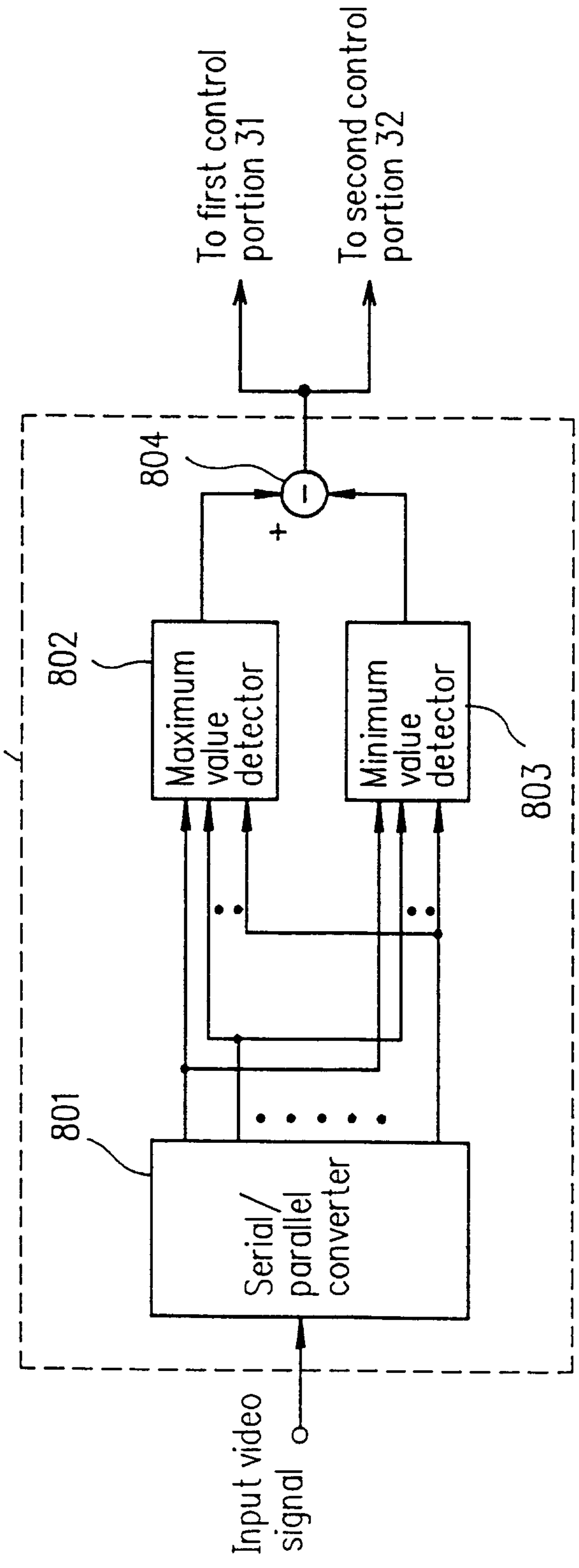

To first control portion 31
To second control portion 32
804
+
45
802
Maximum value detector
Minimum value detector
803
801
Serial/parallel converter
Input video signal

FIG. 34

FIG.35

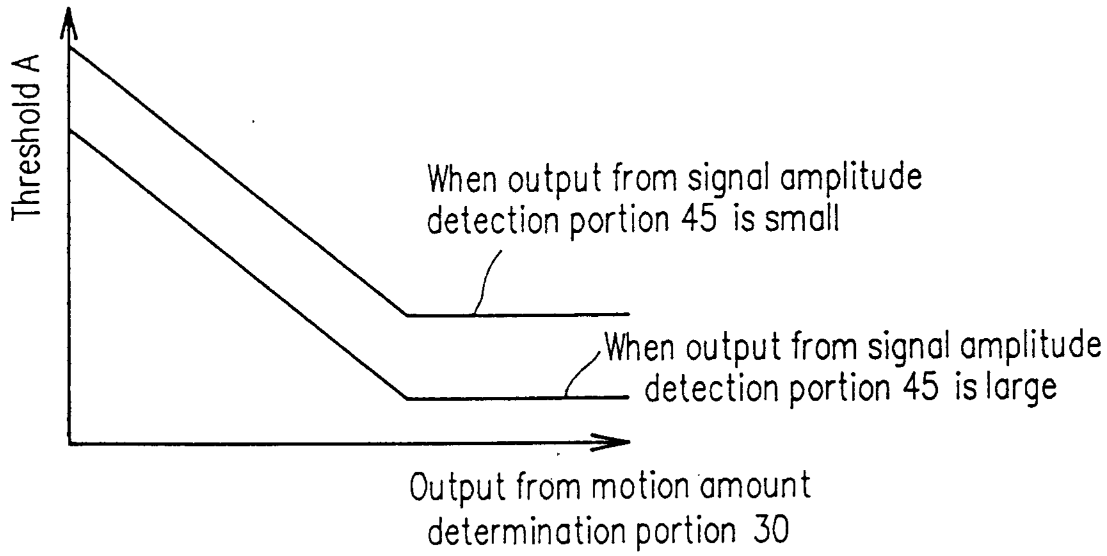

Threshold A
When output from signal amplitude detection portion 45 is small
When output from signal amplitude detection portion 45 is large
Output from motion amount determination portion 30

FIG.36

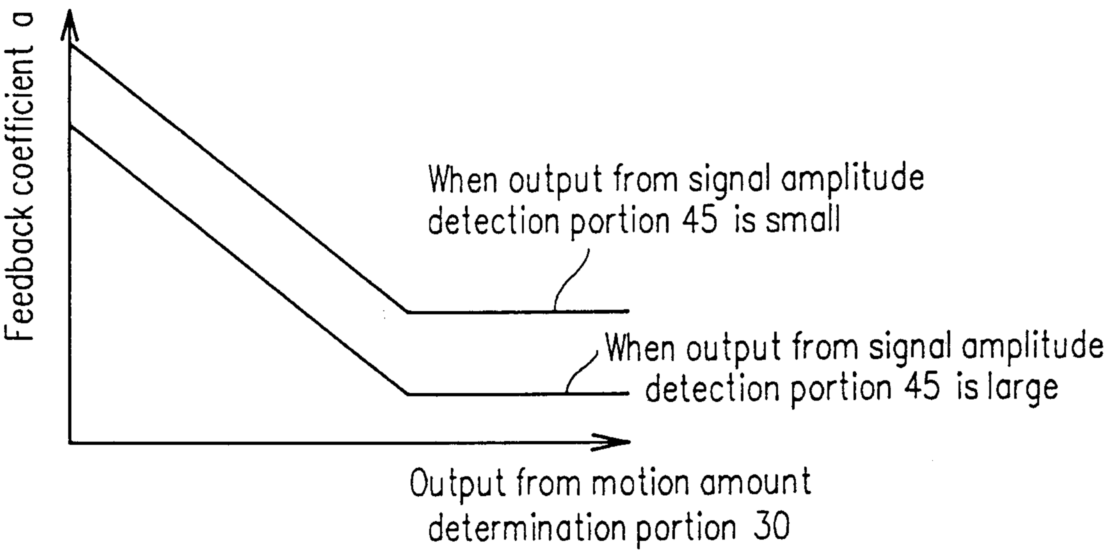
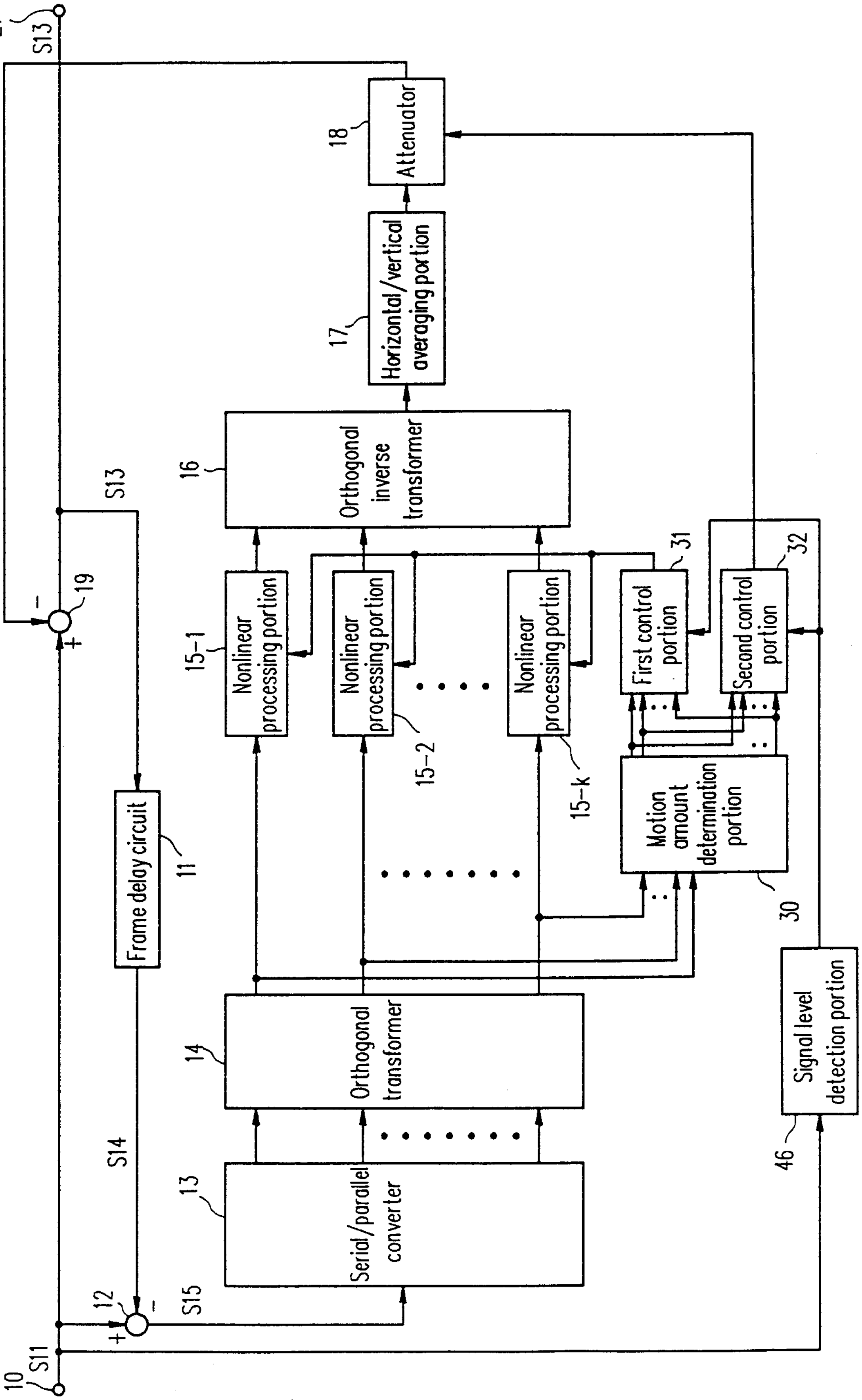

Feedback coefficient a
When output from signal amplitude detection portion 45 is small
When output from signal amplitude detection portion 45 is large
Output from motion amount determination portion 30

FIG. 37


500
10
S11
21
S13
12
S15
S14
Serial/parallel converter
13
Orthogonal transformer
14
Frame delay circuit
11
Nonlinear processing portion
15-1
Nonlinear processing portion
15-2
Nonlinear processing portion
15-k
Orthogonal inverse transformer
16
Horizontal/vertical averaging portion
17
Attenuator
18
19
S12
S13
First control portion
31
Second control portion
32
Motion amount determination portion
30
Signal level detection portion
46

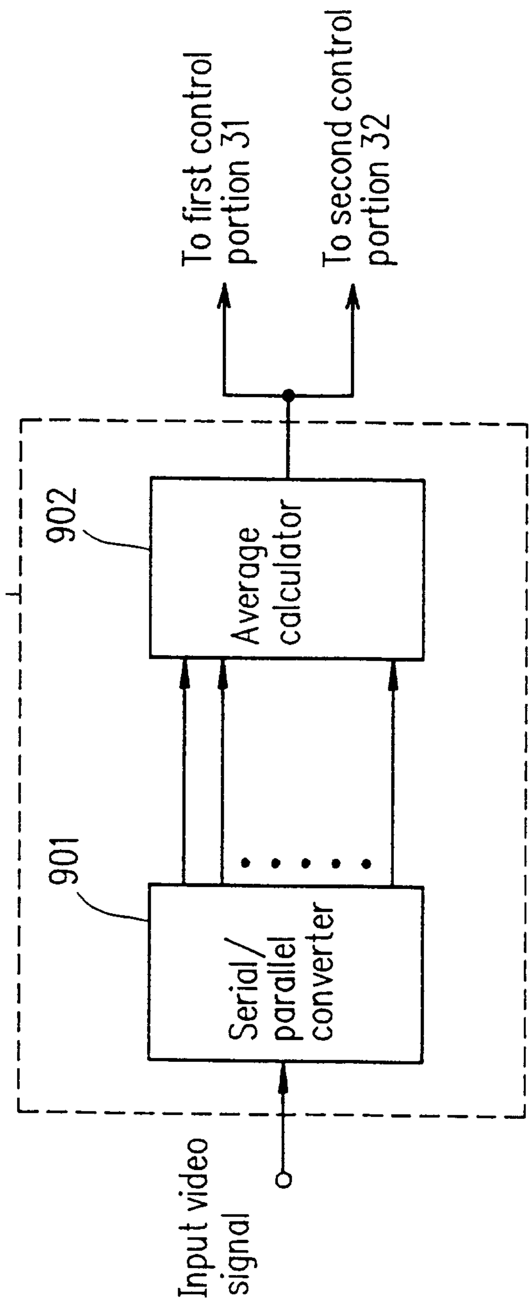

To first control portion 31
To second control portion 32
46
902
Average calculator
901
Serial/parallel converter
Input video signal

FIG. 38

FIG. 39

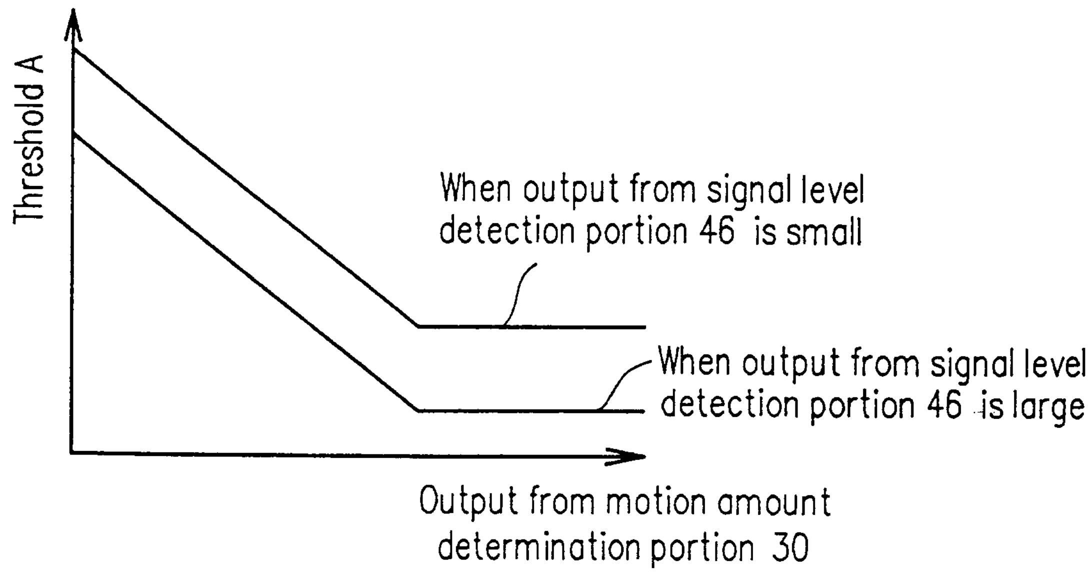

Threshold A
When output from signal level detection portion 46 is small
When output from signal level detection portion 46 is large
Output from motion amount determination portion 30

FIG. 40

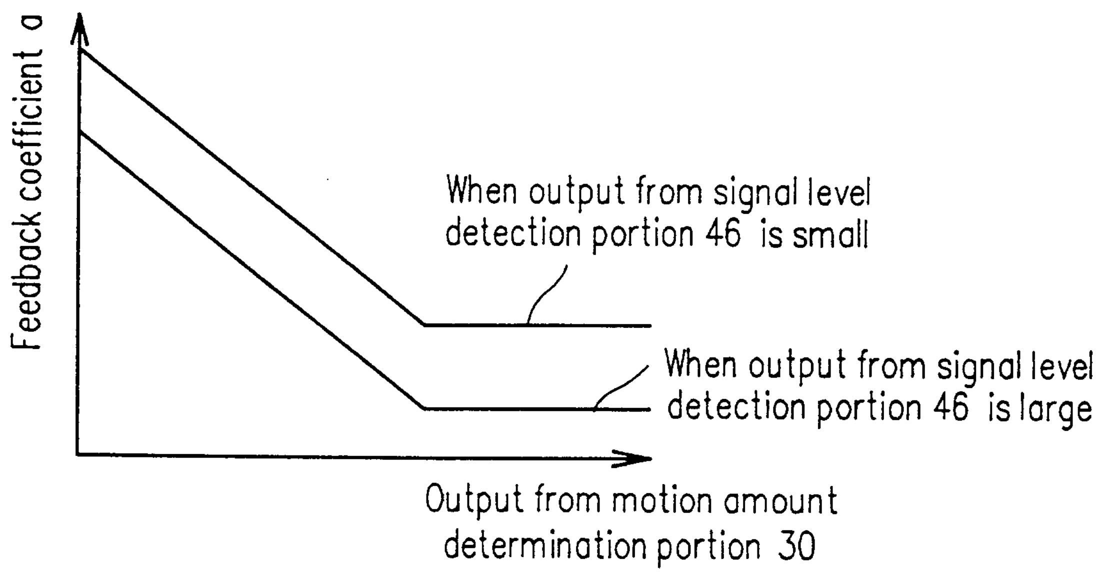

Feedback coefficient a
When output from signal level detection portion 46 is small
When output from signal level detection portion 46 is large
Output from motion amount determination portion 30

FIG. 41

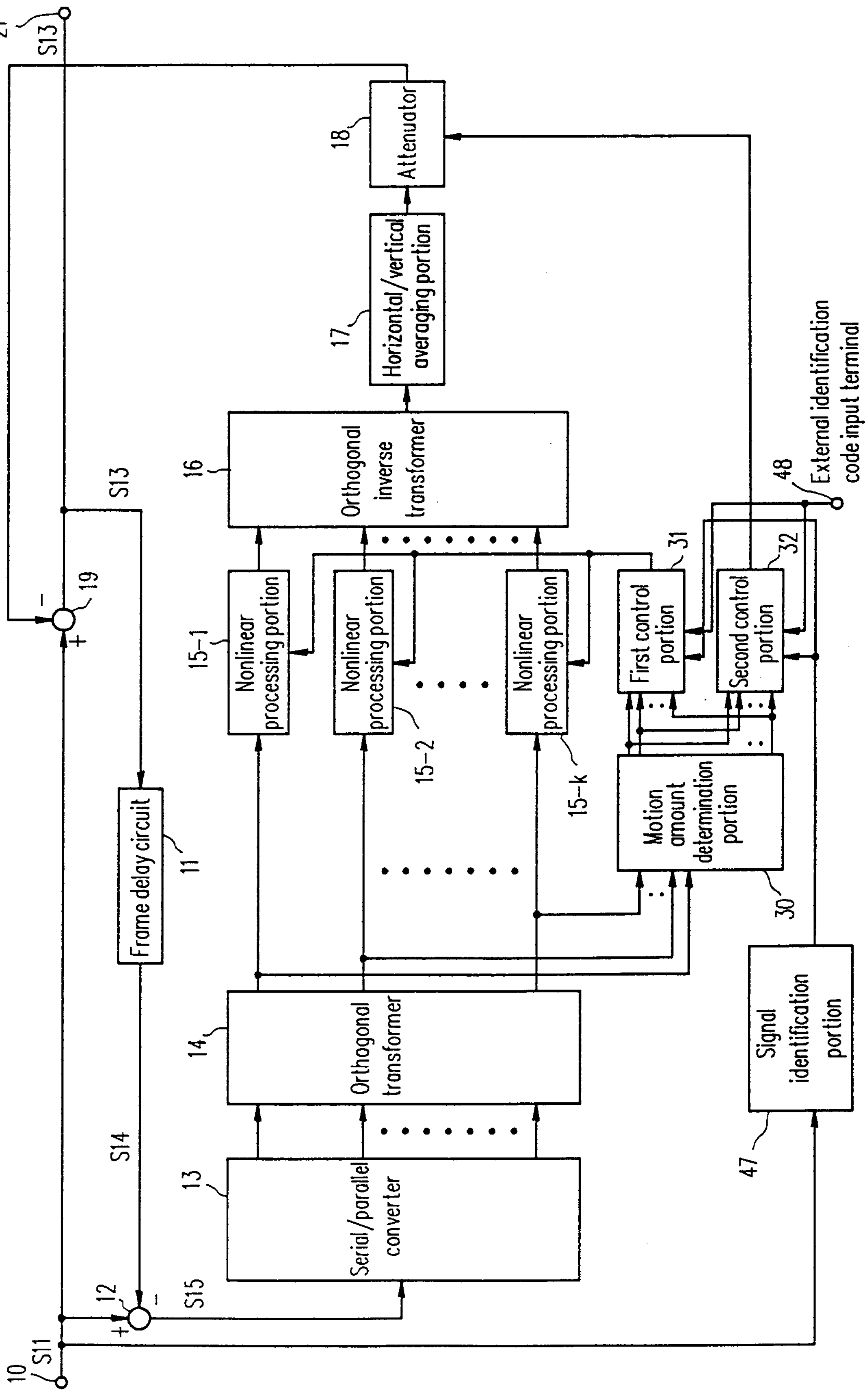

600
10
S11
12
+
-
S15
13
Serial/parallel converter
14
Orthogonal transformer
S14
Frame delay circuit
11
15-1
Nonlinear processing portion
Nonlinear processing portion
15-2
Nonlinear processing portion
15-k
Motion amount determination portion
30
First control portion
31
Second control portion
32
16
Orthogonal inverse transformer
17
Horizontal/vertical averaging portion
18
Attenuator
19
S12
S13
21
S13
48
External identification code input terminal
Signal identification portion
47

FIG. 42

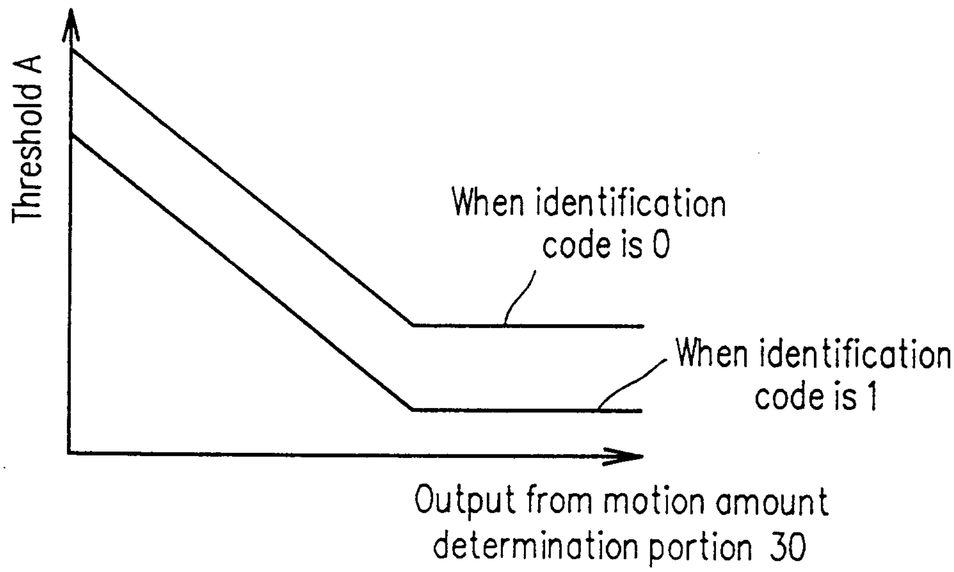
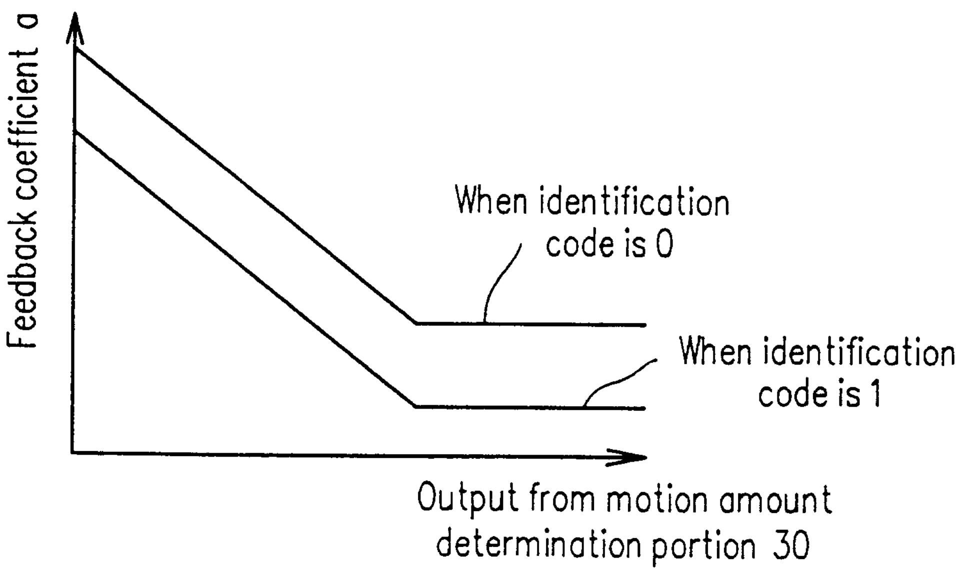

Threshold A
When identification code is 0
When identification code is 1
Output from motion amount determination portion 30

FIG. 43


Feedback coefficient a
When identification code is 0
When identification code is 1
Output from motion amount determination portion 30

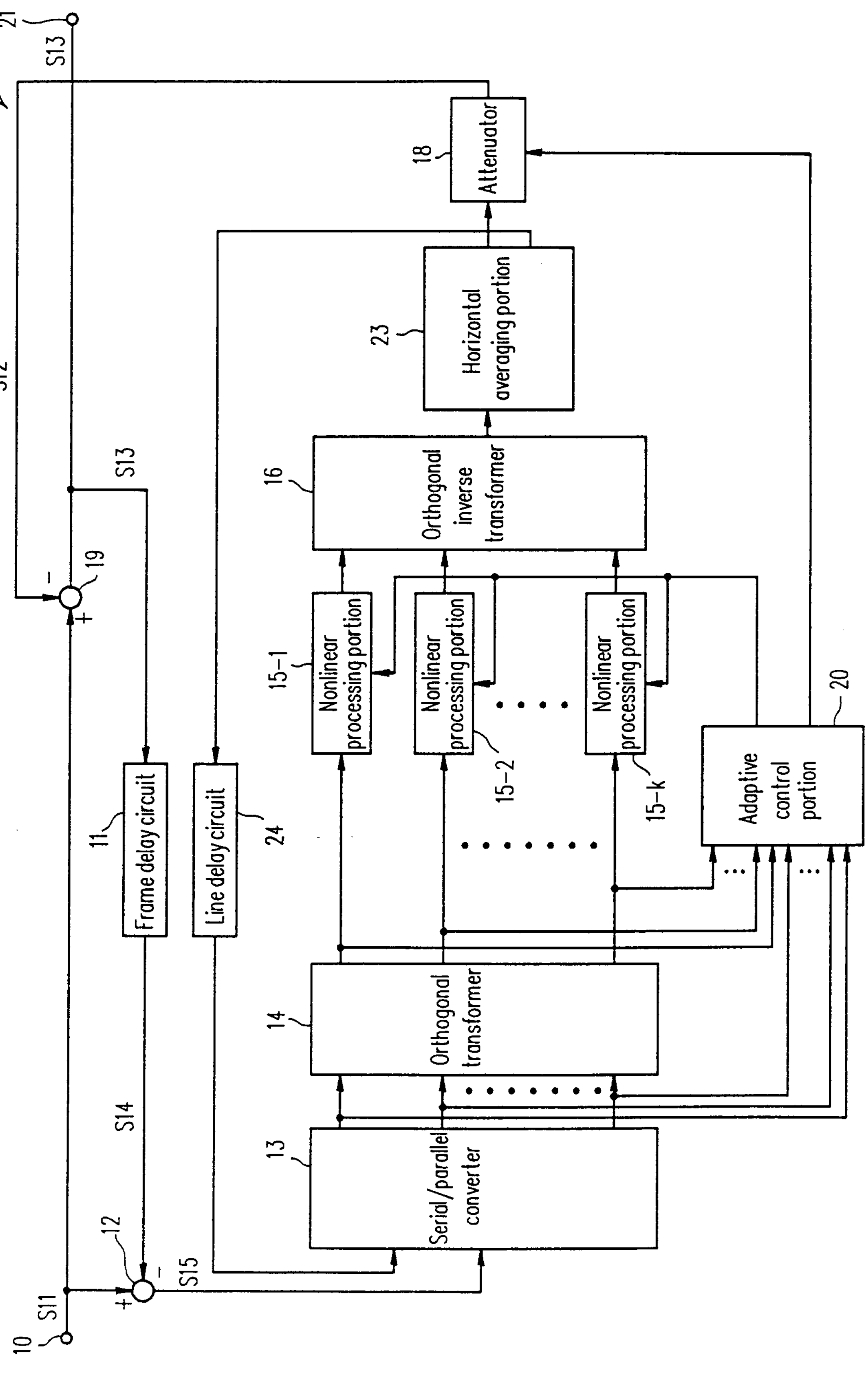

700
10
S11
+
12
−
S15
S14
11
Frame delay circuit
24
Line delay circuit
S13
19
+
−
S12
S13
21
13
Serial/parallel converter
14
Orthogonal transformer
15−1
Nonlinear processing portion
15−2
Nonlinear processing portion
15−k
Nonlinear processing portion
16
Orthogonal inverse transformer
23
Horizontal averaging portion
18
Attenuator
20
Adaptive control portion

FIG. 44

FIG. 45

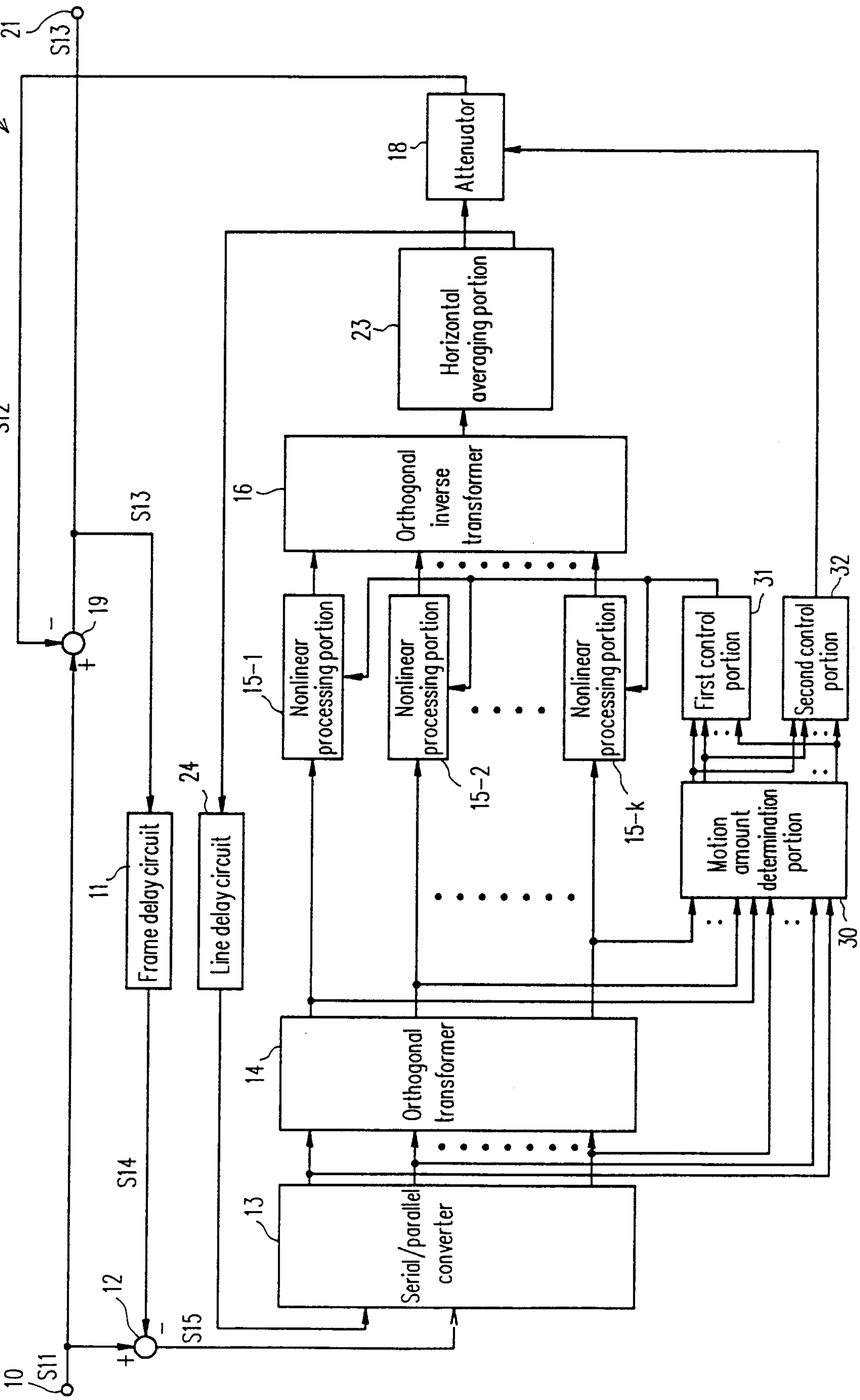

800
10
S11
12
S15
S14
11
Frame delay circuit
24
Line delay circuit
19
S12
S13
21
13
Serial/parallel converter
14
Orthogonal transformer
15-1
Nonlinear processing portion
15-2
Nonlinear processing portion
15-k
Nonlinear processing portion
16
Orthogonal inverse transformer
23
Horizontal averaging portion
18
Attenuator
30
Motion amount determination portion
31
First control portion
32
Second control portion

FIG. 46

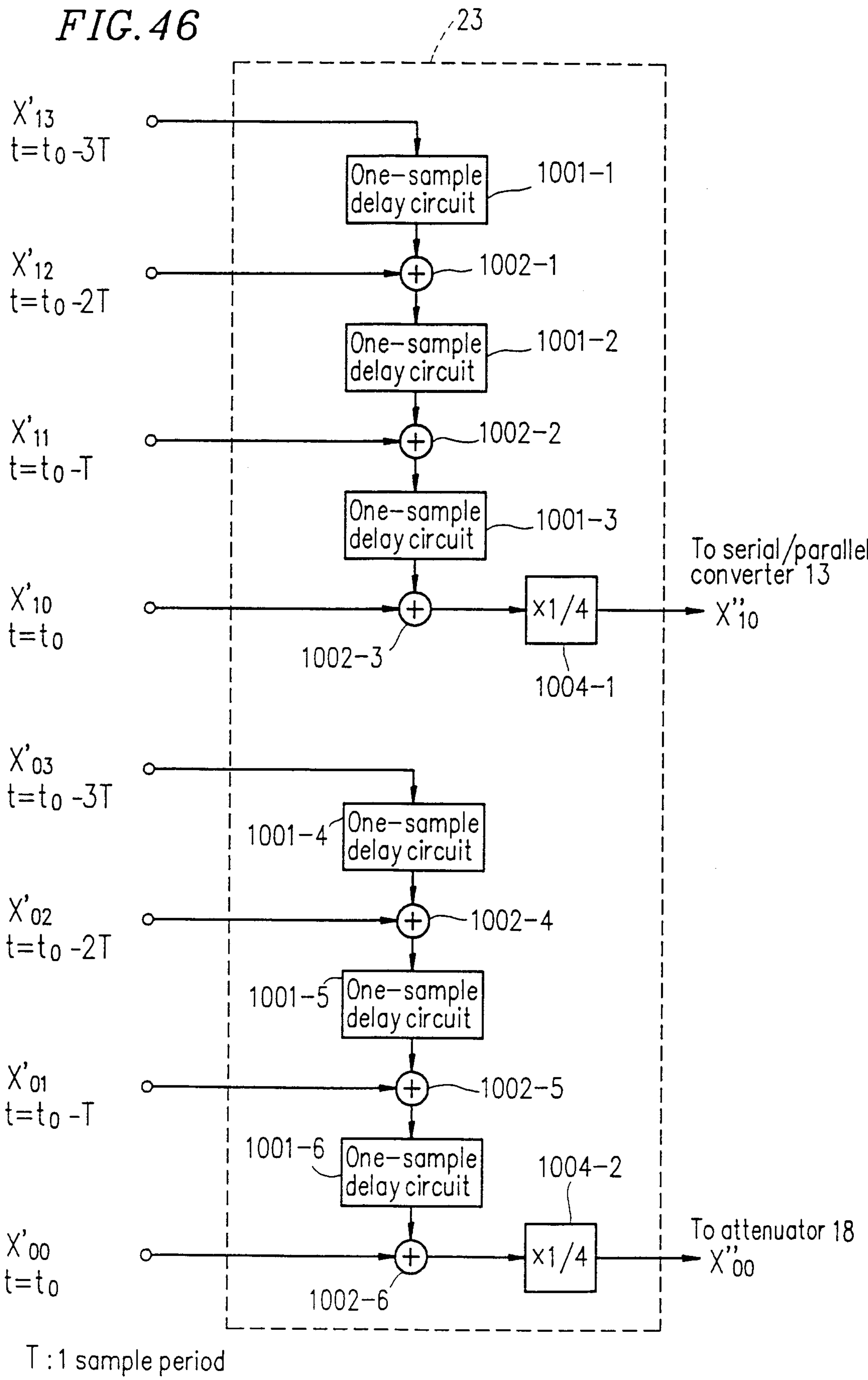

23
X'13
t=t0 -3T
One-sample delay circuit
1001-1
X'12
t=t0 -2T
1002-1
One-sample delay circuit
1001-2
X'11
t=t0 -T
1002-2
One-sample delay circuit
1001-3
To serial/parallel converter 13
X'10
t=t0
x1/4
X''10
1002-3
1004-1
X'03
t=t0 -3T
1001-4
One-sample delay circuit
X'02
t=t0 -2T
1002-4
1001-5
One-sample delay circuit
X'01
t=t0 -T
1002-5
1001-6
One-sample delay circuit
1004-2
To attenuator 18
X'00
t=t0
x1/4
X''00
1002-6
T : 1 sample period

FIG. 47

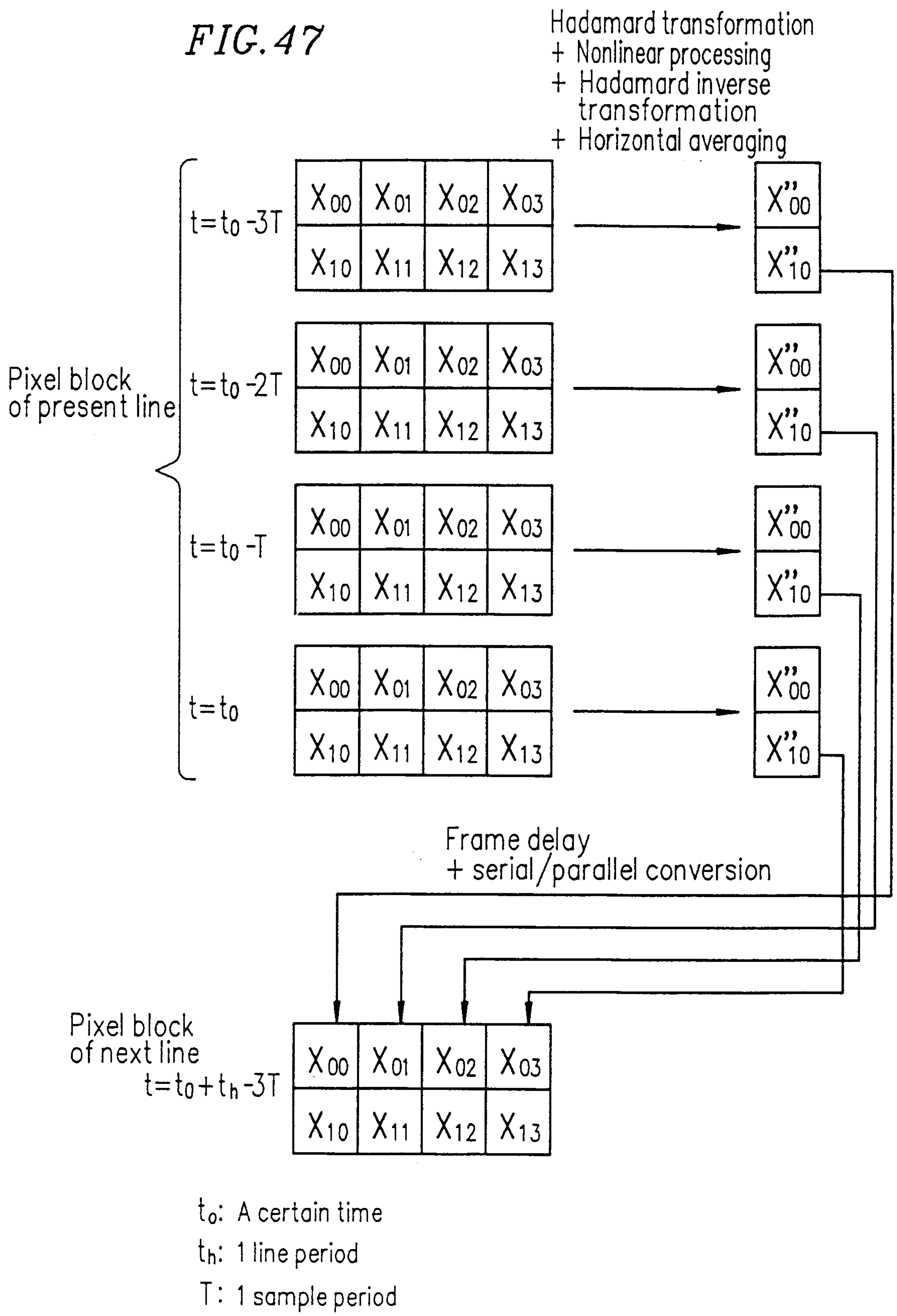

Hadamard transformation
+ Nonlinear processing
+ Hadamard inverse transformation
+ Horizontal averaging
Pixel block of present line
t=t0 -3T
t=t0 -2T
t=t0 -T
t=t0
X00 X01 X02 X03
X10 X11 X12 X13
X''00
X''10
Frame delay
+ serial/parallel conversion
Pixel block of next line
t=t0+th-3T
t0: A certain time
th: 1 line period
T: 1 sample period

FIG.48 PRIOR ART

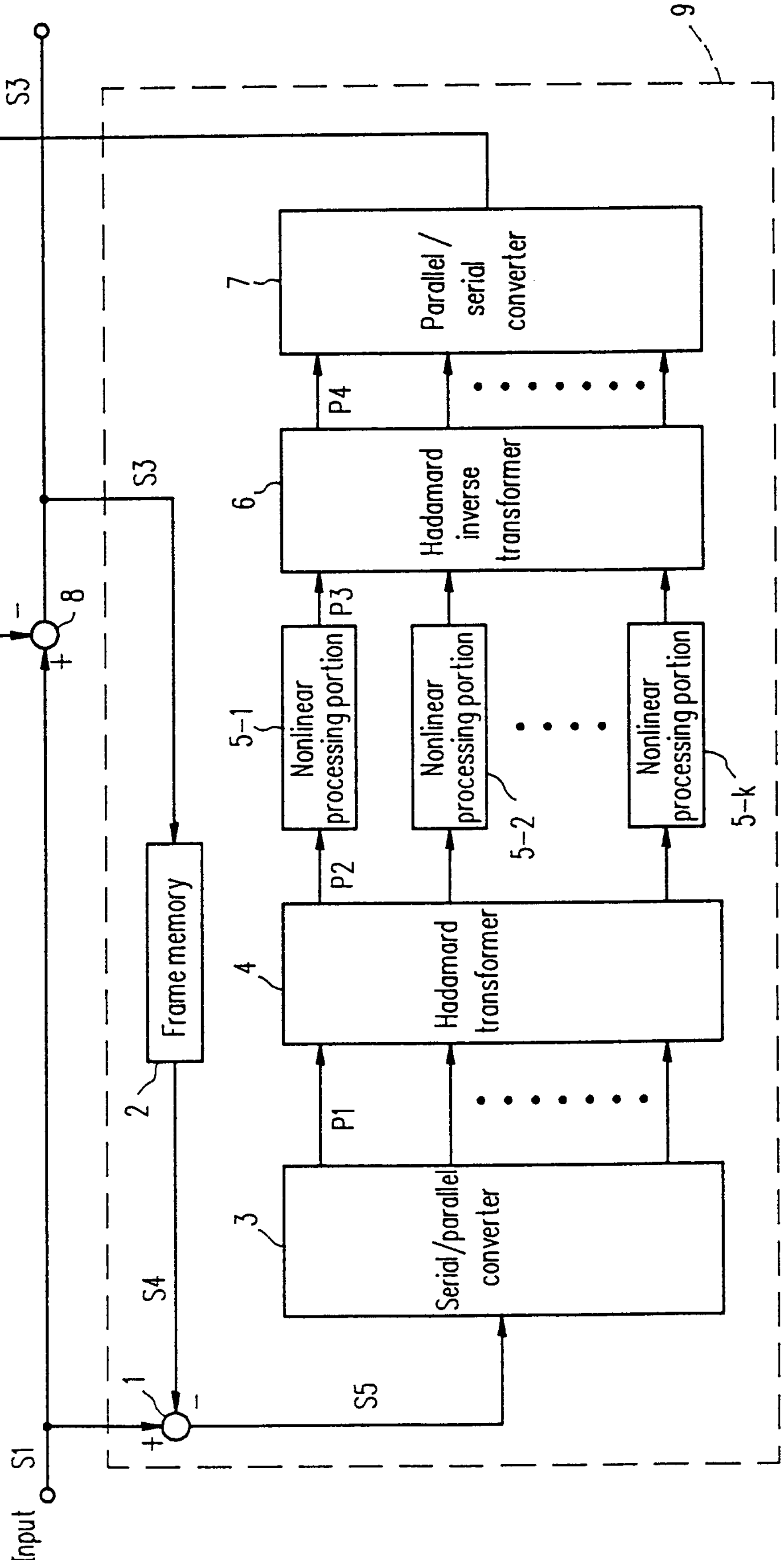
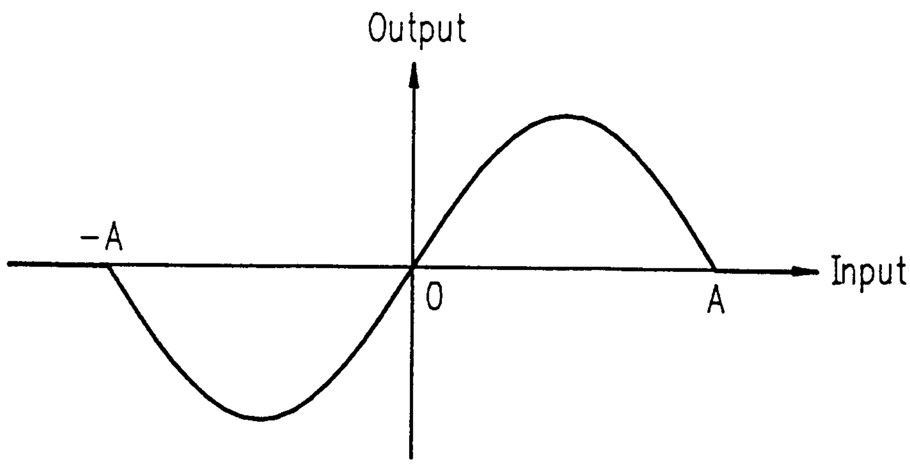


FIG. 49



PRIOR ART